

**SCHEDULE 2**  
**PERFORMANCE STANDARDS**

TABLE OF CONTENTS

	<b>Page</b>
Part I - GENERAL.....	1
Part II - PERFORMANCE STANDARDS – GENERAL OPERATIONS.....	3
1) General.....	3
2) Exterior Appearance of Utility Facilities.....	6
3) Utility Marking, GIS Mapping and Asset Management.....	6
4) Safety.....	7
5) Emergency Response and Unplanned Outages.....	8
6) Procedures for Planned Outages.....	10
7) Design Standards.....	10
8) Material and Equipment Management.....	11
9) Personnel and Operations.....	11
10) Environmental.....	13
11) Utility Office Functions.....	16
12) Interagency Coordination.....	16
13) University Department Office Cooperation.....	17
14) Public Relations and Media Interactions.....	17
15) Service Vehicles.....	18
16) Complaints and Inquiries.....	19
17) Building Emergency Action Plan.....	19
18) Continuity Management Plan.....	20
19) Information Technology, Communications and Connectivity.....	21
20) Performance Standards for Capital Improvements, Energy Conservation Measures and Material Changes.....	22
21) Concessionaire Compressed Air System.....	22
Part III - PERFORMANCE STANDARDS – CHILLED WATER SYSTEM.....	24
1) Temperature Requirements.....	24
2) Pressure Requirements.....	24
3) Line of Demarcation between Concessionaire and University.....	24
4) Metering.....	25
5) Efficiency.....	26
6) Design Standards.....	27
7) Unplanned Outage.....	27
8) Redundancy.....	29
9) Water Quality.....	29

Part IV - PERFORMANCE STANDARDS – STEAM AND CONDENSATE SYSTEM .....	31
1) Temperature Requirements .....	31
2) Pressure Requirements .....	31
3) Line of Demarcation between Concessionaire and University .....	32
4) Metering .....	32
5) Efficiency .....	34
6) Design Standards .....	34
7) Unplanned Outage .....	35
8) Redundancy .....	36
9) Fuel Procurement, Operations and Storage .....	37
10) Boiler water storage.....	37
Part V - PERFORMANCE STANDARDS – ELECTRIC SYSTEM .....	38
1) Power Requirements.....	38
2) Line of Demarcation; Concessionaire, University, and AEP .....	38
3) Metering .....	39
4) Design Standards .....	40
5) Unplanned Outage .....	41
6) Redundancy .....	41
7) Distribution System Switching.....	43
Part VI - PERFORMANCE STANDARDS – NATURAL GAS SYSTEM .....	44
1) Natural Gas Quality.....	44
2) Line of Demarcation; Concessionaire, University, and Columbia Gas .....	44
3) Metering .....	44
4) Design Standards .....	45
5) Compliance with Public Utility Commission of Ohio (“PUCO”) Regulations .....	45
6) Unplanned / Unscheduled Outage .....	46
7) Redundancy .....	47
Part VII - PERFORMANCE STANDARDS – GEOTHERMAL SYSTEM .....	48
1) Temperature, Flow and Quality Requirements .....	48
2) Line of Demarcation Between Concessionaire and University.....	48
3) Metering .....	49
4) Efficiency .....	50
5) Unplanned / Unscheduled Outage .....	50
6) Redundancy .....	51
LIST OF APPENDICES .....	52

## Part I - GENERAL

### Introduction and Purpose of Performance Standards

These Performance Standards and any Appendices thereto, are provided pursuant to Article 6 of the Long-Term Lease and Concession Agreement (the “Concession Agreement”) for the Ohio State University’s Utility System and Utility System Operations. The Performance Standards and Appendices are incorporated and made part of the obligations under the Concession Agreement.

The Utility System is comprised of five individual Utilities, specifically the: (i) the portion of the Utility System that generates, distributes and returns chilled water (the “Chilled Water System”); (ii) the portion of the Utility System that generates, distributes and returns steam and condensate (the “Steam and Condensate System”); (iii) the portion of the Utility System that distributes natural gas (the “Natural Gas System”); (iv) the portion of the Utility System that distributes electricity (the “Electric System”); and (v) the portion of the Utility System that generates and distributes geothermal energy (the “Geothermal System”).

The purpose of the Performance Standards is to: (i) provide the minimum general requirements for the operations and maintenance of the University’s Utility System and provide standards governing Utility System Operations as required by the Concession Agreement and are not inclusive of all of the Concessionaire’s responsibilities; (ii) aid in the development of an Operations Plan (as defined herein) to be developed annually by the Concessionaire for the Utility System; (iii) incentivize the Concessionaire to minimize the time during which the Utility System experiences outages and (iv) ensure that the Utility System is operated and maintained in accordance with Prudent Industry Practices.

Terms used and not otherwise defined in these Performance Standards shall have the meanings ascribed to them in the Concession Agreement. Any approvals or consent required under these Performance Standards shall be governed by the procedure outlined in Section 1.15 of the Concession Agreement. Unless otherwise stated herein or in the Concession Agreement, any Modification to the requirements set forth in these Performance Standards or Appendices thereto, shall be governed by Section 6.3 of the Concession Agreement. Any references to a governmental entity, industry standard organization or University department shall include any successor to such entity, organization or department. Any references to “degrees” shall, unless otherwise specified herein, mean “degrees Fahrenheit.” To the extent that any term or provision specified herein conflicts with any term or provision of the Concession Agreement, the Concession Agreement shall govern.

The Concessionaire shall perform all duties and tasks and all other responsibilities required by these Performance Standards in conformance with Prudent Industry Practices, and the Concessionaire shall keep the Utility System in good condition and repair throughout the Term of the Concession Agreement. If the Concessionaire fails to meet these Performance Standards, it shall be subject to the procedures in the Concession Agreement for addressing such failures.

If deficiencies or situations affecting minimum standards for performance develop during the Term that are not specifically noted herein, it is the Concessionaire's responsibility to correct the deficiencies and manage such situations such that the Utility System will be maintained in the condition required by these Performance Standards.

## Part II - PERFORMANCE STANDARDS – GENERAL OPERATIONS

### 1) General

- a) The Concessionaire shall propose a plan with respect to the operation, repair, maintenance and replacement of the Utility System in accordance with these Performance Standards and the Concession Agreement (the “Operations Plan”) The Operations Plan shall include and satisfy at a minimum, all requirements and all components of the Performance Standards and Prudent Industry Practices. The Concessionaire shall submit such Operations Plan to the University for its review within 180 days after Closing and as further required herein. The University will review the Operations Plan and where appropriate, will provide comments for Concessionaire’s consideration. The Concessionaire shall perform all components of the Operations Plan. The Operations Plan shall cover each Fiscal Year. The Utility System must have an appropriate maintenance and repair program/plan to provide a safe and satisfactory level of service and to maximize Utility System service life in accordance with these Performance Standards. To the extent that any term or provision of the Operations Plan conflicts with any term or provision of these Performance Standards, the Performance Standards shall govern.
- b) All operations, repairs, replacement and maintenance activities shall be carried out in a good and workmanlike manner so as to ensure continuous safety for users of the Utility System and to sustain the value of the Utility System as an asset. Condition assessments and inspections shall follow Prudent Industry Practices and recognized national standards as set forth herein.
- c) The Concessionaire must update and submit its Operations Plan to the University no later than 90 days prior to the beginning of each Fiscal Year. The University will review and if necessary, comment on the Operations Plan. The Concessionaire shall submit a revised Operations Plan for the start of the Fiscal Year. If the Concessionaire does not submit an Operations Plan by the commencement of such Fiscal Year, the Operations Plan for the preceding Fiscal Year shall remain in place until an updated Operations Plan is submitted. Notwithstanding the above, any proposals subject to University Approval as part of the Concessionaire’s Annual Budget or Five Year Plan, must comply with Articles 4 and 7 of the Concession Agreement.
- d) The Operations Plan shall specify how the Concessionaire has considered, trained, addressed, and planned for all operational, repair, maintenance and replacement activities in connection with the Utility System and has established protocols, procedures, responsibilities, and minimum requirements to operate, repair, maintain and replace the Utility System in accordance with these Performance Standards and the Concession Agreement and Prudent Industry Practices.
- e) As part of the Operations Plan, the Concessionaire shall include a maintenance management program for the Utility System. The maintenance management

program shall, at a minimum, meet Prudent Industry Practices and shall include all predictive, preventive, and general Emergency maintenance procedures for the Utility System, including life safety systems and a cleaning and maintenance schedule.

- f) The Concessionaire shall maintain records related to its maintenance of the Utility System in accordance with Section 3.12 of the Concession Agreement. The records regarding maintenance of the Utility System required to be retained by the Concessionaire shall include the following:
  - i. Status of Utility System Assets with disposition of breakdowns, deteriorating conditions, failure to start, significant decrease in capacity or performance (> 5%);
  - ii. Total maintenance spend for the Fiscal Year for the repair costs and labor hours for each individual Utility and the Concessionaire Compressed Air System and the individual work orders associated therewith;
  - iii. One, three and five-year projection of life expectancies of equipment that would be considered Capital Improvements based upon maintenance performed and manufacturer's recommendations;
  - iv. Annual inspections of boiler internals;
  - v. State of Ohio Certificate(s) for boilers;
  - vi. Annual inspections required by the Occupational Safety and Health Administration ("OSHA") for all cranes and hoists;
  - vii. Annual assessments of all Natural Gas System master meter systems; and
  - viii. The preventative maintenance data specified in Section II.1.(j) of these Performance Standards.
- g) The Concessionaire shall include in its Operations Plan a proposed plan for its expenditures to extend the useful life of any and all components of the Utility System, including planned replacements or any additions thereto.
- h) Currently, maintenance activities are managed through AiM (Asset Inventory Management by Asset Works). The Concessionaire shall either continue to use the AiM system for the Utility System or utilize a maintenance management system of its own choosing if the cost of such system is approved by the University as part of the Annual Budget.
- i) Predictive Maintenance
  - i. "Predictive Maintenance" is defined as the specific maintenance actions performed on Utility System Assets, in the event that a Utility System

Asset's current condition is below the required standards, rather than maintenance based on a schedule. The Concessionaire shall provide the Predictive Maintenance necessary to maintain the Utility System in good condition and repair.

- ii. The Concessionaire shall determine in its reasonable discretion what Predictive Maintenance is required and shall keep records of its Predictive Maintenance in accordance with Section 3.12 of the Concession Agreement. Such records shall include, but not be limited to, the following:
  - 1. Record of unplanned boiler, generator, transformer and chiller malfunctions , even if these outages do not result in a loss of service;
  - 2. Vibration levels and alignment records for rotating equipment with Predictive Maintenance conditions based on revolutions per minute and shaft length tables;
  - 3. Thermal scans and operating temperatures for electrical equipment;
  - 4. Oil testing and contaminant levels;
  - 5. Inspections of chiller condensers, evaporators and tube conditions;
  - 6. Chilled water plant operating efficiencies based on the limits described in Part III, Section 5 of these Performance Standards; and
  - 7. Steam boiler fuel use based on the limits described in Part IV, Section 5 of these Performance Standards.

j) Preventive Maintenance

- i. "Preventive Maintenance" is defined as maintenance on the Utility System based on a pre-determined schedule.
- ii. The Concessionaire shall create and maintain a Preventive Maintenance program as part of the Operations Plan (the "Preventive Maintenance Schedule"). Such Preventive Maintenance Schedule must be in accordance with Prudent Industry Practices, including but not limited to applicable Operations and Maintenance Best Practices Industry Manuals. The Concessionaire shall perform the Preventive Maintenance in accordance with the Preventive Maintenance Schedule.

k) Emergency Maintenance

- i. “Emergency Maintenance” is defined as the maintenance necessary to restore operation to equipment, systems, or components in the Utility System that have failed to operate as required.
  - ii. The Concessionaire shall perform all Emergency Maintenance as promptly as possible within time limits agreed to by the Parties and if applicable, adhere to the Unplanned Outage (as defined herein) requirements set forth herein.
- l) In order to properly assist the University in the comprehensive planning for, efficient management of, effective repair of, and controlled access to, the public ways on the Columbus Campus and to lessen the public inconvenience of uncoordinated work in the Public Way while promoting the general public health, safety, and welfare, the Concessionaire shall adhere to the Comprehensive University Pavement and Public Way Management Policy as set forth in Appendix Y.

**2) Exterior Appearance of Utility Facilities**

- a) The Concessionaire shall maintain the exterior appearance of Utility Facilities in accordance with the University’s design standards applicable to the Columbus Campus, provided in Appendix F (the “Design Standards”), as may be updated from time to time. Changes to the exterior appearances of Utility Facilities, including but not limited to the color and lighting of such Utility Facilities and any signage thereon, shall require prior written approval of the University.

**3) Utility Marking, GIS Mapping and Asset Management**

- a) The Concessionaire shall provide utility marking of the Utility System in accordance with established University practices for utility marking, as set forth in Appendix A, Standard Operating Procedures for Surveying and Utility Marking and in conformance with the Ohio Revised Code and Prudent Industry Practices. The utility marking process shall include:
  - i. Support design activities during project planning and development;
  - ii. Provide pre-excavation marking for all construction and maintenance projects;
  - iii. Provide line locating and elevation during installation of new equipment; and
  - iv. Contact Ohio Utilities Protection Services (“OUPS”) for marking of buried Utility System distribution assets before commencing digging activity.
- b) The Concessionaire shall provide mapping updates to reflect modifications to the existing Geographic Information System (“GIS”) for the Utility System including



mapping of all Utility System Assets that are abandoned and not removed during the Term. Such information and updates shall be provided in a format and include details as requested by the University.

- i. The Concessionaire shall reasonably cooperate with the University in connection with the GIS, which contains information regarding both Utility Facilities as well as other facilities which are not part of the Utility System, in connection with any changes, updates or modifications to the Utility System.
- c) The Concessionaire shall be responsible for ensuring the GIS is updated in a timely manner to accurately depict the state of the existing Utility System. The Concessionaire shall enter updated mapping of the Utility System into the GIS within 72 hours of any material change including addition, modification, repair, or abandonment of any portion of the Utility System.
- d) The Concessionaire shall provide regular mapping updates to the GIS to include surface feature updates and repairs and non-material changes, every 6 months.
- e) The Concessionaire shall annually update asset management information pursuant to ISO standard (or its successor).

#### **4) Safety**

- a) The Concessionaire shall develop and adhere to safety and security standards in operating, maintaining, repairing and replacing the Utility System which standards, at a minimum, meet Prudent Industry Practices. The Concessionaire shall develop and document policies and procedures to ensure the security and safety of the Utility System that, at a minimum, meet current policies or procedures provided in Appendices B, C, D, N, and all applicable Memorandums of Understanding (“MOUs”) with the University Department of Public Safety. (See also Part II, Section 5. a), herein.) Such policies and procedures shall be included in the Operations Plan.
  - i. In addition, the electrical safety program shall be in compliance with all applicable Laws and requirements, as may be amended from time to time, including standards established by OSHA as well as the National Fire Protection Association (“NFPA”) (NFPA 70E), including applicable training and qualifications programs.
- b) The Concessionaire shall maintain the security of the Utility System Assets located in the Tunnels in compliance with the requirements listed in Appendix Z. In addition, the Concessionaire shall coordinate with the University’s facility group responsible for the Tunnels, the University’s Department of Public Safety and local law enforcement, as appropriate, provided that, absent the University’s negligence or willful misconduct, the University shall not be liable to the Concessionaire for any damage or loss of the Utility System Assets located in the Tunnels.

- c) The Concessionaire shall secure the industrial control systems within the Utility System to NIST Standard 800-82.
- d) The Concessionaire shall promptly notify the University's Department of Public Safety and local law enforcement upon learning of suspected or alleged criminal activity concerning the Utility System.
- e) The Concessionaire shall abide by all regulations of the University's Department of Public Safety.
- f) The University's Department of Public Safety shall have access at all times (24-hours a day, seven days a week) to all plants, buildings and any other Utility Facilities on the Columbus Campus which are required to be maintained by the Concessionaire.
- g) The Concessionaire shall be responsible for ensuring that safety security alarms, including fire alarms which are part of the Utility System, are directly tied to the life and safety systems of the University.
- h) Except as otherwise provided in Concession Agreement, Concessionaire shall ensure that any and all cameras installed by Concessionaire in Utility Facilities shall provide a direct feed to the University's security office, use the University's network and meet the University's specifications.
- i) All Utility Facilities on the Columbus Campus shall be subject to inspection by University Fire Prevention.
- j) The Concessionaire shall adhere to any and all applicable policies, practices and procedures set forth in the University's Health and Safety Guide, as may be amended.
- k) As part of the Concessionaire's obligation to comply with all Laws, the Concessionaire shall comply with all OSHA requirements including but not limited to, safety training programs and injury reporting and logs.

**5) Emergency Response and Unplanned Outages**

- a) The Concessionaire shall follow current Emergency Support Function-12, Utility Outage Procedures, Emergency Operations Plan, and Emergency Response Plans referenced in Appendices B, C, D and N.
- b) The Concessionaire shall provide personnel to support all procedures and activities required by the University during an Emergency and or failure of the Utility System which failure had not previously been approved by the University (each, an "Unplanned Outage") in order to provide the required Utility Services.
- c) During an Unplanned Outage, the Concessionaire shall work cooperatively with the University until Utility Services are restored. During any Unplanned Outage,

the Concessionaire shall follow all communication procedures for an Emergency and all applicable Emergency response plans provided by the University, including working with a representative contact designated by the Director of Communications and Marketing (hereinafter referred to as the “Communications Contact”). The Concessionaire shall provide automatic text message alerts immediately after any Emergency or Unplanned Outage to designated University contacts.

- d) The Concessionaire shall adhere to the procedures and requirements for an Unplanned Outage set forth in these Performance Standards for each individual component of the Utility System.
- e) The Concessionaire shall designate a representative to participate in the University’s Emergency Operations Center (the “EOC”), which representative shall:
  - i. Attend meetings at the reasonable request of the University;
  - ii. Obtain training required by the University; and
  - iii. Assist in coordination with the University to respond during Emergencies.
- f) The Concessionaire shall adhere to a priority list as established by the University for restoration of the Utility System following an Unplanned Outage. The restoration priority list is attached hereto as Appendix R, and may be updated from time to time. Any such update shall not be considered a modification to these Performance Standards subject to Section 6.3 of the Concession Agreement.
- g) During any Unplanned Outage, the Concessionaire shall send prompt updates to Service2Facilities, the EOC and the Director of Marketing and Communication for Administration and Planning or the designated Communications Contact.
- h) At least 48 hours before (i) any home football game, (ii) any visit by a head of state or political dignitary, (iii) any significant political event, or (iv) any other event which the University provides advance written notice of to the Concessionaire (each, a “Major Event”), the Concessionaire shall:
  - i. Prepare a response plan for an Unplanned Outage, in accordance with the University’s then-existing mechanical and Electric System access and response practices and the procedures described in Appendix C (the “Utility Outage Procedures”) and promptly implement such plan as necessary; and
  - ii. Provide a subject matter expert as a resource to the University’s Communications Department and the EOC before and during such Major Event.

- i) If Concessionaire is not provided with advance notice of a Major Event sufficient to comply with the deadline set forth in Section 5 h), above, Concessionaire shall provide the listed information as soon as practicable following notification of any Major Event.
- j) In the event an Unplanned Outage impacts the Columbus Campus, the Concessionaire shall, at the University's request, provide a subject matter expert as a resource to the University's Communications Department for the duration of the need arising from the Unplanned Outage.

**6) Procedures for Planned Outages**

- a) The Concessionaire shall follow the Utility Outage Procedures for requirements for communicating a planned outage of the Utility System (a "Planned Outage") to the parties identified in Appendix C. Failure to adhere to such requirements shall cause any outage of any part of the Utility System to be deemed an Unplanned Outage. In addition to the requirements set forth in the Utility Outage Procedures, the Concessionaire shall provide notice of such Planned Outage at least 10 Business Days before the Planned Outage.
- b) Prior to a Planned Outage, the Concessionaire shall consult with the University to determine when temporary utility sources (such as electrical generators, boilers or chillers) are necessary to maintain building operations, and the Concessionaire shall provide such temporary utility sources as agreed with the University.
- c) The Concessionaire shall coordinate the restoration of Utility Services following a Planned Outage with the University.

**7) Design Standards**

- a) The Concessionaire shall follow the Design Standards for all portions of the Utility System, unless otherwise provided for herein or approved by the University.
- b) The University retains the right to modify or update the Design Standards, which modification or update shall be deemed a modification of these Performance Standards under Section 6.3(a) of the Concession Agreement. The Concessionaire shall have the opportunity to participate in and provide input on periodic updates to the Design Standards.
- c) The Concessionaire shall comply with all other applicable design standards and codes, including:
  - i. American Society of Mechanical Engineers (ASME);
  - ii. Institute of Electrical and Electronics Engineers (IEEE);
  - iii. National Electric Code (NEC);

- iv. ASME Code for Pressure Piping B31; and
- v. National Fire Protection Association (NFPA).

**8) Material and Equipment Management**

- a) The Concessionaire shall procure all necessary equipment and materials to properly operate the Utility System. Such equipment and material shall be appropriate for its use and, at a minimum, meet Prudent Industry Practices.
- b) The Concessionaire shall include in its Operations Plan its plan for materials management; which shall include:
  - i. A process for procuring materials for the operation of the Utility System;
  - ii. A process for maintaining adequate inventory levels to account for Planned Outages and Unplanned Outages;
  - iii. A plan for maintenance of Concessionaire's storage facilities;
  - iv. A method for staging materials; and
  - v. Minimum levels of certain materials identified as critical by the Concessionaire, below which the Concessionaire shall reorder such materials.
- c) In all events, the Concessionaire shall purchase materials and equipment for use in the Utility System that are:
  - i. Fit and serviceable for the intended purpose and free of defects;
  - ii. UL-listed, if applicable at the time of purchase;
  - iii. Of the type and quality typically used in Comparable Utility Systems.

**9) Personnel and Operations**

- a) Whenever the Concessionaire is required to utilize a qualified engineer, such engineer shall be subject to the University's prior Approval. The Concessionaire shall have the right to provide a list of qualified engineers to the University on an annual basis for the University's approval. The Concessionaire shall then be permitted to utilize any engineer on such list.
- b) As part of its Operations Plan, the Concessionaire shall provide a detailed staffing plan, which shall include, at a minimum:
  - i. Organizational chart(s);
  - ii. Shift planning for normal operations;

- iii. Emergency response staffing and communications contact who is designated to work with the University “Concessionaire Communications Contact.”
  - iv. Position descriptions;
  - v. Screenings / testing, which the Concessionaire shall provide to the University promptly after receipt thereof;
  - vi. Training and employee development;
  - vii. Employee credentials, licenses and other certifications;
  - viii. Diversity and inclusion;
  - ix. Rates of pay; and
  - x. Overtime policies and practices for all employees.
- c) As part of its Operations Plan, the Concessionaire shall include a plan for providing personnel coverage during an Emergency, for both a short-term and long-term closure of the University. Such plan shall include a list of employees designated as serving in "essential," "alternate," or "standby" status during an Emergency, and identify the Concessionaire Communications Contact, for both short-term and long-term closures. The Concessionaire's Emergency staffing and designations shall conform with then-current University policies for Emergency preparedness and for short-term and long-term closures.
- d) Within 30 days after the end of a Fiscal Year, the Concessionaire shall provide information to the University regarding the operations of the Utility System, including:
- i. The results of the metering accuracy auditing program;
  - ii. The results of the chemical, water treatment, and pre-treatment plans;
  - iii. Environmental and regulatory compliance;
  - iv. The implementation of safety programs;
  - v. The effectiveness of utility data systems and IT network security;
  - vi. Plant operating procedures; and
  - vii. Peak Utility System loads and percentage of installed capacity.
- e) The Concessionaire shall support project design reviews and new utility connection planning, design and construction inspections (as defined in Appendices M and H).

- f) The Concessionaire shall plan and execute hot work and energized electrical equipment testing with respect to the Electric System per applicable safety standards including NFPA 70E.
- g) The Concessionaire shall develop and conduct electrical power system studies including load demand, short circuit, electrical coordination, and OSHA arc flash utilizing SKM software and in compliance with all applicable IEEE standards.
- h) The Concessionaire shall maintain and keep up to date the Primary Electrical Service Policy provided in Appendix M.
- i) The Concessionaire shall maintain KY pipe flow and load models at or above the level existing as of the Closing Date or develop mutually acceptable alternative models for the Steam and Condensate System, the Chilled Water System and the Natural Gas System.
- j) The Concessionaire shall comply with the Utility Service Connection and Inspection Standards provided in Appendix H.
- k) The Concessionaire shall provide a 10 minute response time by a person with senior-level, qualified experience directly at the source of the (Emergency or power outage) issue during business hours (6:00 AM to 6:00 PM Monday-Friday) and a 30 minute response time during non-business hours.

**10) Environmental**

- a) In operating the Utility System, the Concessionaire shall comply with applicable Environmental Laws and any and all environmental or sustainability standards, policies or procedures adopted by the University and communicated to the Concessionaire.
- b) The Concessionaire shall instruct its employees and employees of the Operator to conduct all operation, repair, maintenance and replacement work in a manner so as to minimize exposure to Hazardous Substances. The Concessionaire shall notify the University of any planned activity that may disturb building materials containing Hazardous Substances and may require special handling pursuant to applicable Environmental Laws. If advance notice is not practicable, the Concessionaire shall notify the University as soon possible after encountering building materials containing Hazardous Substances on or in the vicinity of the Utility System, and shall cease any activity which would disturb or further disturb hazardous building materials until after Concessionaire has notified and consulted with the University regarding proper handling of such material. If the Concessionaire, in the course of its operation, repair, maintenance or replacement activities, creates a hazardous condition by disturbing or otherwise altering building materials containing Hazardous Substances, the Concessionaire shall manage such Hazardous Substance in accordance with all applicable Environmental Laws and in compliance with University policies and programs

including Asbestos Abatement Standards and Scope of Work set forth in Appendix E.

- c) If the Concessionaire encounters or disturbs any Hazardous Substances in the course of its operations for which the University has retained liability pursuant to Section 3.2(d) of the Concession Agreement, the Concessionaire shall notify the University and shall work with the University to facilitate any University action deemed necessary to comply with applicable Environmental Laws. In any case, Concessionaire shall take measures to avoid causing, exacerbating, or contributing to any hazardous condition or any Release of a Hazardous Substance encountered in the course of its operations. Further, whenever the Concessionaire becomes aware of any Release of a reportable quantity of a Hazardous Substance, the Concessionaire must comply with the notice requirements set forth in Section 8.1(b) of the Concession Agreement.
- d) The Concessionaire shall be responsible for managing and remediating Hazardous Substances Released or encountered in the course of operations, in accordance with all applicable Environmental Laws but only to the extent that such Hazardous Substances are associated with environmental conditions created or caused by Concessionaire after the Time of Closing or such obligations are not otherwise considered to be excluded from liabilities and obligations of Concessionaire pursuant to Section 3.1(d) of the Concession Agreement. In such case, Concessionaire shall notify and coordinate with the University before taking any non-emergency action to address a Release of a Hazardous Substance and shall include the University in any correspondence with regulatory officials regarding the management and remediation of the Hazardous Substance.
- e) In addition to the obligations set forth in Section 11.13 of the Concession Agreement pertaining to the Title V Permit, the Concessionaire shall be responsible for completing and filing all environmental reports and for environmental recordkeeping and monitoring pertaining to the operation of the Utility System as required by the University or as may be required under applicable Environmental Laws. This shall include:
  - i. Fuel Flow Meters Quality Assurance/Quality Control (“QA/QC”) Plan required by Greenhouse Gas Reporting Rule;
  - ii. Predictive Emissions Monitoring System QA/QC Plan, as required by the U.S. Environmental Protection Agency (“EPA”);
  - iii. Boiler 5 Fuel Flow Meters QA/QC Plan required by Ohio NOx Sip Call/Budget Trading Program;
  - iv. Hazard Communication/Globally Harmonized System of Classification and Labeling of Chemicals Plan required by OSHA;
  - v. Reverse Osmosis Plant Wet Weather Plan required by the City of Columbus Division of Sewage and Drains;



- vi. McCracken Slug Discharge Plan required by the City of Columbus Division of Sewage and Drains; and
  - vii. Recordkeeping and reporting for refrigerant storage and leaks.
- f) As part of its obligations under Section 3.12(a) of the Concession Agreement, the Concessionaire shall provide all necessary related operational and environmental data to the University for inclusion in campus-wide regulatory environmental reports.
- g) The Concessionaire shall develop and implement the following plans/programs as required by applicable Environmental Laws:
- i. Spill Prevention Control, and Countermeasure Plan (“SPCC Plan”);
  - ii. Storm water management plan which complies with applicable National Pollutant Discharge Elimination System rules and University requirements;
  - iii. Petroleum storage and tank management program including inspections; and
  - iv. Refrigerant leak monitoring.
- h) Hazardous Substances
- i. The Concessionaire shall not be allowed to use, dispose, treat or store any Hazardous Substances, other than those used in its ordinary course of operations, without written consent by the University.
  - ii. The Concessionaire shall manage all wastes resulting from its operations in accordance with applicable Environmental Laws. All applications, certifications and notifications required for the generation, storage and disposal of Hazardous Substances are the responsibility of the Concessionaire.
- i) Wastewater
- i. Industrial discharge from operation of the Utility System shall meet the requirements of all Laws, including Environmental Laws and any directives provided by a Governmental Authority.
  - ii. Wastewater discharge permits and wastewater discharge operating requirements shall be the responsibility of the Concessionaire.
  - iii. Preapproval for sludge discharges to City of Columbus sanitary system shall be the responsibility of the Concessionaire.

- j) The Concessionaire shall be responsible for evaluation, recycling and/or disposing of waste generated in the course of Utility System Operations, in compliance with applicable Environmental Laws and in alignment with University policies.
- k) Environmental Emergency
  - i. In the event that the Concessionaire has become aware of a release of Hazardous Substances into the environment due to Utility System Operations, the Concessionaire shall immediately notify the University and the appropriate Governmental Authority in accordance with applicable Laws and applicable University policy.
  - ii. The Concessionaire shall also take immediate steps to remediate any release of Hazardous Substances and to minimize further release of Hazardous Substances into the environment.

#### **11) Utility Office Functions**

The Concessionaire shall establish an office of the Utility System (the “Utility Office”), which shall be staffed by the Utility System Operator personnel.

- a) The Utility Office is the primary point of contact for the University regarding information on the Utility System and Utility System Operations, including Planned Outages, Unplanned Outages, general campus information and event-specific information related to the Utility Facilities and Utility Services.
  - i.

#### **12) Interagency Coordination**

- a) The Concessionaire is required to cooperate with any and all local, state and federal governmental, regulatory and law enforcement agencies.
- b) The Concessionaire's required cooperation may include, but not be limited to:
  - i. Providing access to the Utility Facilities;
  - ii. Closing Utility Facilities for public safety purposes;
  - iii. Disconnecting Utility Services or a portion thereof due to an Emergency or law enforcement situation;
  - iv. Providing access to information contained in any surveillance system;
  - v. Attending planning and operational meetings;
  - vi. Providing a representative in the EOC in the event of a large-scale or critical situation that involves any aspect of the Utility Facilities or the Concessionaire's responsibilities; or

vii. Any other action that is deemed necessary to ensure public safety.

c)

### **13) University Department Office Cooperation**

- a) The Concessionaire will work collaboratively with departments, offices or other entities of the University for efficient, safe and effective Utility System Operations pursuant to the Concession Agreement and these Performance Standards: or as may reasonably requested from time to time by the University.
- b) The Concessionaire's involvement with these departments as it relates to the Utility System may include, but not be limited to:
  - i. Participation in appropriate campus planning meetings including working with the University to coordinate responses to media or other inquiries;
  - ii. Coordination of information and logistical activities to ensure customer utility needs are met;
  - iii. Participation on work teams to plan impacts under numerous scenarios related to planned and unplanned events;
  - iv. Campus Emergency coordination;
  - v. On- and off-campus construction; and
  - vi. Working with University stakeholders to execute plans.

### **14) Public Relations and Media Interactions**

- a) The Concessionaire shall have procedures in place for working with the University and also for interacting with the University community, to the extent requested by the University. All communications about the Utility System directed to the Columbus Campus constituents, or other University stakeholders must be coordinated with and approved by the University. The Concessionaire shall work with the designated University Communications Contact.
- b) The Concessionaire shall work with the University administration to engage the University community and media before, during and after any material event impacting or involving the Utility System or Utility Service, which plan shall be implemented following approval by the University.
- c) The Concessionaire may be contacted by members of the University community and media regarding information pertaining to the Utility System or Utility Service, and the Concessionaire shall, at the University's option, either provide a referral to the appropriate entity (which may include a designated University representative) or a knowledgeable individual to respond directly to the

University community and media. The University reserves the right to take any and all action necessary to ensure effective communication.

#### **15) Service Vehicle Use and Operation**

The Concessionaire will be permitted to utilize service vehicles to facilitate the operations of the Utility System. Because the Concessionaire's service vehicles will also represent the image and character of the University, the following guidelines must be followed for the use of service vehicles:

- a) The Concessionaire must ensure such service vehicles are in good operating condition and must maintain a sufficient inventory of service vehicles to meet the obligations of the Concessionaire at all times.
- b) The Concessionaire shall be responsible for ensuring the safe operation of all service vehicles.
- c) Insurance must be secured and maintained in accordance with the Concession Agreement.
- d) All service vehicles utilized by the Concessionaire must be clean, safe and regularly maintained to ensure safe operation.
- e) The vehicle body must be relatively free from damage. If damage occurs, it must be repaired within a reasonable period of time.
- f) Annual safety inspections must be performed.
- g) All vehicles in use must have a cumulative fleet MPG average which meets applicable Federal fuel-efficiency standards, and must otherwise comply with all Laws and applicable University sustainability standards.
- h) All service vehicles will be clearly identified and bear uniform markings on both sides of the vehicle. These include, but are not limited to:
  - i. Company name; and
  - ii. Vehicle (fleet) number located on the rear of each vehicle.
- i) All service vehicles must be equipped with fully operational "mars lights" or equivalent with flashing yellow caution lights.
- j) The Concessionaire shall develop and implement service vehicle user requirements and procedures including, but not limited to, the following:
  - i. Employees must be properly trained on proper and safe use of service vehicles;

- ii. The Concessionaire must provide standards and procedures for screening service vehicle drivers and maintaining driver records;
  - iii. Service vehicle operators shall not permit unauthorized passengers to utilize the service vehicles at any time; and
  - iv. The Concessionaire shall report all service vehicle accidents on University property to the University within one (1) Business Day following any accident.
- k) Service vehicles are subject to all University parking regulations and procedures.

**16) Utility Service Inquiries**

- a) The Concessionaire shall establish and implement an effective and reliable system for accepting and responding to University questions and comments about Utility System Operations and Utility Services ("Service Inquiries"). Service Inquiries shall be recorded as they are received. The Concessionaire shall maintain a database of Service Inquiries which shall include:
- i. Specific utility service referred to in each Service Inquiry;
  - ii. Details of the Service Inquiry;
  - iii. A description of actions taken by the Concessionaire in response to the Service Inquiry, including corresponding date of actions taken; and
  - iv. Details of how the Service Inquiry was resolved.
- b) The database of Service Inquiries shall be provided to the University upon request.
- c) The Concessionaire shall respond to all non-outage related Service Inquiries within one (1) Business Day of receipt thereof and shall resolve all Service Inquiries in a timely manner.
- d) The Concessionaire must accept and respond to University Service Inquiries and outage reports on a 24-hour basis.

**17) Building Emergency Action Plan**

- a) As part of its Operations Plan, the Concessionaire shall include a Building Emergency Action Plan ("BEAP") for the evacuation of Utility Facilities in the event of an Emergency that permits staff to quickly and safely evacuate each Utility Facility. The BEAP must include, at a minimum, the following:
- i. Evacuation procedures and roles;
  - ii. Evacuation routes;

- iii. Shelter-in-place location(s);
  - iv. Emergency communications;
  - v. Training and drill schedules; and
  - vi. Emergency Utility Facility contact.
- b) The BEAP will be created in conjunction with the Continuity Management Plan, as defined below, and the University's Enterprise Continuity Management Program. The BEAP shall be submitted to designated University departments, as necessary. This plan must be evaluated on an annual basis and updated as needed. The Concessionaire shall make personnel and other resources available to conduct Emergency drills or Emergency planning required by the University as requested.
- c) The personnel training program shall include training on all Emergency activities and procedures required by Law. Documentation of enrollment and satisfactory completion shall be supplied to the University and updated at least annually.

**18) Continuity Management Plan**

- a) As part of the Operations Plan, the Concessionaire shall include a Continuity Management Plan ("CM Plan") to establish procedures and protocols in relation to continuing or recovering services following an Emergency. This CM Plan must include, at a minimum, the following:
- i. Plan overview, scope, and assumptions document;
  - ii. Response teams with named individuals assigned to each team;
  - iii. An initial call tree;
  - iv. Contact information for key team members, vendors, departments, agencies, and university stakeholders;
  - v. Initial response activities in the following categories: command/leadership, communications, HR/employee care, financials, IT, and assessment;
  - vi. A list of all Utility Services, prioritized in order of recovery, with recovery time objectives assigned to each;
  - vii. One named individual as a the contact in charge of recovery and one as an alternate contact for each service;
  - viii. A description of how each service will be continued or recovered in each of the following three scenarios:
    - 1. Unavailability of majority of staff;

- 2. Unavailability of key applications and/or equipment;
- 3. Unavailability of the building/Utility Facility;
- ix. List of minimally-required resources for recovery;
- b) This CM Plan will be created in conjunction with the BEAP and the University's Enterprise Continuity Management Program, and it shall be submitted to other University departments, as required by the University. The Concessionaire must evaluate the CM Plan on at least an annual basis and update the CM Plan as needed.

**19) Information Technology, Communications and Connectivity**

- a) The Concessionaire shall work with the Office of Chief Information Officer (“OCIO”) to develop and implement appropriate interconnection protocols and security measures whenever the Concessionaire is connecting to any electronic network, communications system or other electronic media owned, operated or managed by the University or its agents.
- b) Prior to connecting to or using the University's electronic network, communications system or other electronic media, Concessionaire shall submit to the OCIO for review, and approval all of Concessionaire's electronic network security protocols, application security protocols, data storage protocols, access management procedures, and any other information that the OCIO determines necessary to protect the integrity and security of the University's electronic systems and communications networks. In addition, any use of the University's electronic network or other information systems shall be subject to the policies and requirements contained in Appendix X.
- c) All communications wires and optical fibers used by the Concessionaire within the geographic boundaries of the University in performing its duties under the Concession Agreement shall be provided by the University to the Concessionaire. Any costs charged by the University for communications equipment may be included as O&M costs or Capital Improvement costs pursuant to the terms of the Concession Agreement. The University shall provide such optical fiber and/or wired communications to the Concessionaire at the cost normally charged by the OCIO to internal University customers, but in no event will that cost be in excess of a then-current average market rate charged by local providers of materially similar services.
- d) \Subject to the Terms of the Concession Agreement and except as caused by the University's negligence or willful misconduct, Concessionaire assumes all risk and agrees to indemnify, defend and hold harmless the University from any and all actions, claims, costs, demands, or suits arising out of or resulting from the Concessionaire's connection to or use of any electronic network, communications system or other electronic media owned, operated or managed by the University or its agents.

- e) Prior to deploying or using any wireless communications within the geographic boundaries of the University, Concessionaire shall submit to the OCIO for review, approval and acceptance, a detailed description of Concessionaire's proposed wireless communications technology and any other information that the OCIO determines necessary. If required by the OCIO, the Concessionaire will implement all reasonable measures necessary (including abatement) to protect the integrity and security of current wireless communications networks and other equipment operating at the University.
- f) Conditions and requirements for Concessionaire's use for all wired network (IP), dark fiber, cellular data, analog telephone, or 802.11 WiFi communications systems on the Columbus Campus, including service-level agreements, security protocols and operating standards for such use are set forth in Appendix W.

**20) Performance Standards for Capital Improvements, Energy Conservation Measures and Material Changes**

- a) The Concessionaire shall develop, evaluate, propose and, if Approved, implement or construct, all Capital Improvements, Energy Conservation Measures ("ECM") and Material Changes in accordance with the relevant terms of the Concession Agreement, these Performance Standards and the process and protocols for Capital Improvements and Material Changes (Capital Improvements and Material Changes Protocol) as set forth in Appendix W and the process and protocols for ECMs ("ECMs Protocol") as set forth in Appendix V.
- b) The process and standards included in Appendix W are provided to assist the Concessionaire in developing any proposal for a Capital Improvement or Material Change, to align with University's capital planning process and to ensure compliance with University planning, design and construction standards. This process includes working with a designated University representative (University Representative) to facilitate project review and input where appropriate. Appendix W lists information required to facilitate the University's review of draft proposals as well as the standards for implementing and constructing Approved Capital Improvement projects.
- c) The process and standards included in Appendix V are provided to assist the Concessionaire in developing any proposal for ECMs, to align with the University's capital planning process and to ensure compliance with University planning, design and construction standards. This process includes working with a designated University Representative to facilitate project review and input where appropriate. Appendix V lists information required to facilitate the University's review of draft proposals as well as the standards for implementing and constructing Approved ECM projects.

**21) Concessionaire Compressed Air System**



- a) In accordance with Section 3.25 of the Concession Agreement, the line of demarcation for the Concessionaire Compressed Air System (comprised of the air generators located in the McCracken Power Plant and distribution system attached thereto), includes the distribution piping up and until the 3" and 4" shut-off valves located inside the McCracken Power Plant, just before the pipelines enter the north McCracken Power Plant Tunnel.
  
- b) The Concessionaire will ensure that Concessionaire Compressed Air System continues to deliver the same volume and quality of compressed air delivered as of the Closing Date, including providing air pressure of at least 80 pounds per square inch (psi), measured at the McCracken Power Plant shutoff valve and otherwise in accordance with these Performance Standards and the Concession Agreement.

### **Part III - PERFORMANCE STANDARDS – CHILLED WATER SYSTEM**

#### **1) Temperature Requirements**

- a) The Concessionaire shall ensure that the water being distributed by the Chilled Water System is maintained at a temperature at or below 42 degrees at each of the following points in the Utility System:
  - i. TIT-TS-CWS6 process area 069 chiller for McCracken Power Plant;
  - ii. TIT-10008 process area in the South Campus Central Chiller Plant; and
  - iii. TIT-10008 process area in the East Regional Chilled Water Plant.

#### **2) Pressure Requirements**

- a) The Concessionaire shall ensure that the water being distributed by the Chilled Water System maintains pressure at the following locations within the ranges specified below:
  - i. McCracken Power Plant:  $\geq 68$  psig; measured at PSCWS process area 069chiller;
  - ii. South Campus Central Chiller Plant:  $\geq 68$  psig; measured at PIT-10009 process area; and
  - iii. East Regional Chilled Water Plant:  $\geq 68$  psig; measured at PIT-10009 process area.
- b) The Concessionaire shall maintain a positive bridge flow, defined as the differential chilled water pressure between supply and return piping at each of McCracken Power Plant, South Campus Central Chiller Plant and East Regional Chilled Water Plant. Short-term negative bridge flows are permissible during periods of high building demand so long as chilled water supply temperature does not exceed 42.5 degrees for 20 minutes or longer.

#### **3) Line of Demarcation between Concessionaire and University**

- a) Except as otherwise described herein, the line of demarcation for the Chilled Water System is depicted in Appendix L3 (which include separate diagrams for: Plant Chilled Water Direct Connect to Building; Plant Chilled Water Indirect Connect to Building; Central Chilled Water + Direct Connect District Chilled Water Distribution; and Central Chilled Water + Indirect Connect District Chilled Water Distribution). Appendix L3 serves as a representative diagram of the Chilled Water System. See also Appendix K3 for a map of the Chilled Water System.

- i. All building/secondary pumps, heat exchangers and associated building piping shall not be considered part of the Chilled Water System; and
  - ii. For line of demarcation between the tunnel system and the utility piping system, see Appendix Z.
- b) Appendix L3 denotes those portions of the Chilled Water System for which the Concessionaire will have full responsibility for Operation and Maintenance (“O&M”) and for capital expenditures for system upgrades and changes (“Capital Expenditures”) and those portions of the Chilled Water System for which the Concessionaire will have responsibility for Capital Expenditures but for which the University will retain responsibility for the O&M (herein referred to as “Capital Only”). Except as otherwise described herein and as depicted in Appendix L3, the Concessionaire shall be responsible for Capital Expenditures and O&M for the Chilled Water System to the building isolation valves. For Chilled Water district systems, the Concessionaire shall be responsible for Capital Only from the building isolation valves to the metering assemblies. The Concessionaire shall have responsibility for Capital Expenditures and O&M for all meter assemblies within the Chilled Water System.

#### 4) **Metering**

- a) The Concessionaire shall purchase, install, maintain and operate building chilled water smart meters in accordance with the requirements set forth in the Concession Agreement and as further outlined herein.
  - i. The Concessionaire shall ensure the meters are accurate and calibrated to the manufacturer’s recommendations and
  - ii. During the smart meter implementation period, the Concessionaire shall provide the University with all information from the Concessionaire-installed smart meter readings, in a format prescribed by the University and in manner that allows the University to maintain, without interruption, the University’s then-current internal system for usage recording and billing. The Concessionaire-installed smart meters must be read at consistent intervals and at least every 25 to 35 days, throughout the smart meter implementation period.
- b) As part of the Operations Plan, the Concessionaire shall include a plan to ensure metering accuracy and a metering accountability metric for such meters that are part of the Chilled Water System. For the avoidance of doubt, the Concessionaire shall adhere to all requirements set forth in Division 33 of the Design Standards attached as Appendix F, for flow, pressure, and temperature accuracy.
- c) The Concessionaire shall either continue to use the existing Schneider Electric SE licensed software program that the University uses to acquire, monitor and maintain Utility consumption data within the Utility System (the “Instep System”) or use metering software of its choosing, subject to the Approval of the Annual

Budget by the University. In either case, the Concessionaire shall provide the University reasonable access to view the real-time meter data upon request.

- d) The Concessionaire shall ensure electronic metering occurs at a minimum of one (1) minute intervals.
- e) The Concessionaire shall maintain accurate software, monthly meter data, and billing.
- f) The Concessionaire shall ensure that all new building connections to the Chilled Water System are metered at the time of connection using networked smart meters meeting the specifications set forth in the Concession Agreement.
- g) Plant production meters
  - i. Production meters for the Chilled Water System must be in service when equipment is operating, functioning properly and reporting to a data system readily accessible by the University. If a primary production meter fails, the associated equipment shall be shut off until the failure is resolved.
  - ii. Historical data on plant production meters shall be maintained in 1-minute intervals and readily accessible for the University’s review. Raw 1-minute data shall be recorded in a database that cannot be edited by the Concessionaire. The Concessionaire shall allow the University to poll the 1-minute data daily via an “open database connectivity” connection for long term storage. Data will be time stamped with the date, hour (in 24 hr. format) and minute.
  - iii. Meters shall be calibrated yearly and maintained in accordance with the manufacturer’s recommendations. Calibrations shall be completed using a calibrator with a National Institute of Standards and Technology (“NIST”) traceable calibration certificate that is no more than 365 days old. The Concessionaire shall notify the University three (3) Business Days in advance of meter calibration and allow the University to observe the calibration procedure.

**5) Efficiency**

- a) At a minimum, the Concessionaire must meet the kilowatt per ton scorecard requirements for the Chilled Water System in existence at the Time of Closing:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>kW/Ton</b>	0.9	0.85	0.8	0.78	0.78	0.808	0.808	0.808	0.808	0.808	0.9	0.9
<b>Weighted Yearly Average (kW/Ton) - .808</b>												

- b) The Concessionaire shall operate the Chilled Water System plants in a manner to ensure reliability as well as optimization of energy and conservation of natural

resources. The Concessionaire shall use commercially reasonable efforts to continuously improve the operating efficiency and use of resources including water for the Chilled Water System.

## **6) Design Standards**

- a) The Concessionaire shall maintain and keep up to date an accurate Chilled Water System hydraulic model, which may be KY Pipe or other similar modeling software, in order to:
  - i. Inform new buildings being connected to the Chilled Water System of the design pressure drop requirements based on system hydraulic models; and
  - ii. Verify and maintain system flow velocities according to design standards.
- b) The Concessionaire shall stress analyze main Chilled Water System distribution piping when subject to ambient temperatures over 100 degrees, including certain of those located in Tunnels.
- c) The Concessionaire shall cause the Chilled Water System to adhere to the following chilled water pipe velocity limits:
  - i. Piping (existing) to be limited to 11 feet per second (“fps”) at peak flow;
  - ii. Piping (new) to be installed at 7.5 fps at peak flow for headers;
  - iii. Follow American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (“ASHRAE”) 90.1 guidelines for peak flow of branch lines; and
  - iv. New and existing HDPE piping velocity at peak flow shall not exceed manufacturer’s burst pressure in the event of sudden velocity changes.
- d) When chilled water distribution piping is not placed in a Tunnel or trench box, it shall be direct buried.
- e) The Concessionaire shall follow the Utility Service Connection and Inspection Standard in Appendix H and associated construction inspection matrix and jurisdictional agreements with Ohio Division of Industrial Compliance.

## **7) Unplanned Outage**

- a) An Unplanned Outage for the Chilled Water System shall mean the occurrence of one of the following:
  - i. Chilled water supply temperature exceeds 44.5 degrees at any of McCracken Power Plant, South Campus Central Chiller Plant and East

- Regional Chilled Water Plant for 10 continuous minutes or more or 30 cumulative minutes in any 60 minute period;
- ii. Chilled water supply is interrupted to a building due to a closed or inoperable distribution valve, leakage, pipe failure, or other system failure;
  - iii. Pressure of chilled water header supply drops below 40 psig at the South Campus Central Chiller Plant or 60 psig at the McCracken Power Plant or East Regional Chilled Water Plant; or
  - iv. The Concessionaire fails to provide sufficient notice for such outage to be a Planned Outage.
- b) The Concessionaire shall meet or improve upon historical averages for Chilled Water Unplanned Outages including:
- i. No more than 26 Unplanned Outages per Fiscal Year; and
  - ii. No more than 187 lost customer connection hours (defined as duration of the outage in hours multiplied by the number of buildings affected by the outage) per Fiscal Year.
- c) The Concessionaire shall notify the University and building operators via Service2Facilities if there is excessive chilled water loop makeup of more than 25 gallons per minute for five continuous minutes or more as indicated by the existing alarm.
- d) If an Unplanned Outage for the Chilled Water System occurs which causes a loss of service to a portion of the Utility System, the Concessionaire shall promptly and diligently, including 24-hour a dayservice, commence active work, regardless of potential delay by others, to correct the Chilled Water Unplanned Outage and restore service; unless otherwise approved by the University in its sole discretion.
- e) If operational issues occur that result in a high loop temperature event (greater than 44.5 degrees for 10 minutes) for the Chilled Water System, the Concessionaire shall:
- i. Notify Service2Facilities;
  - ii. Notify Medical Center Operations, if such Chilled Water Unplanned Outage occurs at the South Campus Central Chiller Plant;
  - iii. Begin necessary corrective action; and
  - iv. Provide updates every 60 minutes to Service2Facilities if incident exceeds 60 minutes or more.

## **8) Redundancy**

- a) Where possible, the Concessionaire shall maintain an N+1 level of redundancy for the Utility System Assets that make up the Chilled Water System. “N+1” is defined as the ability to meet seasonal peak load assuming the largest capacity Utility System Asset of the Chilled Water System is non-functional.
- b) If the Chilled Water System is below an N+1 level of redundancy, the Concessionaire shall promptly and diligently commence active work to correct the loss of system reliability within 48 hours.
- c) The Concessionaire shall maintain standby generators, or other backup equipment approved by the University, at Smith Substation and McCracken Power Plant with the ability to produce 6,100 kilowatts allocated to the Steam and Condensate System or the Chilled Water System, depending on seasonal requirements, or as directed by the University during a power outage. The University has the right to increase such requirement in its reasonable discretion, which shall be deemed a modification of these Performance Standards under Section 6.3(a) of the Concession Agreement.
- d) The Concessionaire shall maintain standby generators, or other backup equipment approved by the University, at the Generator Plant and the ability to produce 4,500 tons of Emergency chilled water capacity at the South Campus Central Chiller Plant. The University has the right to increase such requirement in its reasonable discretion, which shall be deemed a modification of these Performance Standards under Section 6.3(a) of the Concession Agreement.
- e) The Concessionaire shall perform biennial black start testing of the South Campus Central Chiller Plant and generators and building chilled water load shedding systems that make up the Chilled Water System. The date and time of each test shall be discussed with the University and agreed upon no less than 30 days in advance of such test.

## **9) Water Quality**

- a) The Concessionaire shall prepare a chemical and water treatment plan, as part of the Operations Plan, which shall cover the Chilled Water System and the Geothermal System. Such plan shall cover frequency and validation of measurement and testing as well as the following items at a minimum:
  - i. Scale and corrosion;
  - ii. Excessive reversion of polyphosphate to orthophosphate;
  - iii. Microbiological control;
  - iv. Copper corrosion;

- v. Maintaining closed loop water chemistry of nitrite and Adenosine Triphosphate (“ATP”);
- vi. Cooling tower and condenser water:
  - 1. Scale and corrosion inhibitor;
  - 2. Bleach or other biocide;
  - 3. Monitor and maintain cooling tower cycles in the range of 5 to 8 cycles as necessary to keep heat transfer services clean while minimizing water usage; and
  - 4. Legionella testing twice per Fiscal Year on six cooling tower systems, and a cooling tower in each plant must be part of such test.
- b) The Concessionaire shall comply with the Legionella Exposure Control Plan provided in Appendix I as well as risk analysis required by ASHRAE 188.
- c) The Concessionaire shall require the chilled water systems in a new building that is to be connected to the Chilled Water System to be flushed and treated to central plant standards by the building owner or construction team before connecting to the Chilled Water System.
- d) The Concessionaire shall review and approve new building chilled water flush and startup plans per the Chilled Water Construction Checklist provided in Appendix H.



## **Part IV - PERFORMANCE STANDARDS – STEAM AND CONDENSATE SYSTEM**

### **1) Temperature Requirements**

- a) The Concessionaire shall operate steam boilers to produce superheated steam at nominal 600 degrees, as measured at the super heater outlet temperature transmitter.
- b) The Concessionaire shall maintain and operate the heating and hot water skid 24 hours a day, 365 days a year at the East Regional Chilled Water Plant. It shall be operated according to the following reset schedule:
  - i. If the outside ambient temperature is 40 degrees or greater, the supply temperature shall be 120 degrees;
  - ii. If the outside ambient temperature is between 0 and 40 degrees, the supply temperature shall increase on a linear proportionate basis up to 180 degrees, such that, for example purposes only, if the outside ambient temperature is 20 degrees, the supply temperature shall be 150 degrees; and
  - iii. If the outside ambient temperature is less than or equal to 0 degrees, the supply temperature shall be 180 degrees.
- c) The Concessionaire must ensure that every building connected to the Steam and Condensate System shall receive superheated steam, measured at the furthest point from McCracken Power Plant, which are currently the following locations:
  - i. Veterinary Medical Center;
  - ii. Brain and Spine Hospital (300 W. 10th Avenue); and
  - iii. Ohio Union.

### **2) Pressure Requirements**

- a) The Concessionaire shall ensure that central steam in the Steam and Condensate System is maintained at 180-190 psig measured at PIC-960 or PIC160 at McCracken Power Plant.
- b) The Concessionaire shall ensure that central steam in the Steam and Condensate System is maintained at 135 psig or higher at
  - i. Veterinary Medical Center;
  - ii. Brain and Spine Hospital (300 W. 10th Avenue); and
  - iii. Ohio Union.

- c) The Concessionaire shall ensure that the vacuum condensate return system is continuously operated at not less than -4” Hg vacuum.

### **3) Line of Demarcation between Concessionaire and University**

- a) Except as otherwise described herein, the line of demarcation for the Steam and Condensate System is depicted in Appendix L4 (which includes separate diagrams for Typical Building Steam Service; Central Steam Distribution + District Steam Distribution; Central Steam + District Heating Hot Water Distribution). Appendix L4 serves as a representative diagram of the Steam and Condensate System. For line of demarcation between the tunnel system and the utility piping system, see AppendixZ. See also Appendix K4 for a map of the Steam and Condensate System.
- b) Appendix L4 denotes those portions of the Steam and Condensate System for which the Concessionaire will have full responsibility for Operation and Maintenance (“O & M”) and for capital expenditures for upgrades and changes (“Capital Expenditures”) and those portions of the Steam and Condensate System for which the Concessionaire will have responsibility for Capital Expenditures but for which the University will retain responsibility for the O &M (herein referred to as “Capital Only”). Except as otherwise described herein and as depicted in Appendix L4, the Concessionaire shall be responsible for Capital Expenditures and O&M for the Steam and Condensate System to the building isolation valves of the steam metering assembly. For Steam and Heating Hot Water district systems, the Concessionaire shall be responsible for Capital Only from the steam metering assembly to the to the satellite building metering assembly. The Concessionaire shall have responsibility for Capital Expenditures and O & M for all meter assemblies within the Steam and Heating Hot Water district systems.
- c) The Steam and Condensate System shall include, for rinse and regeneration water, the sewer manhole / sewer hub in Water Treatment Annex. The Concessionaire shall comply with discharge control procedure when the Olentangy Scioto Interceptor Sewer (OSIS) sewer is surcharged.
- d) The Concessionaire shall be responsible for chemical treatment in the Utility Facilities.

### **4) Metering**

- a) The Concessionaire shall purchase, install, maintain, and operate building steam smart meters in accordance with the requirements set forth in the Concession Agreement and as further outlined herein.
  - i. The Concessionaire shall ensure the meters are accurate and calibrated to the manufacturer’s recommendations.

- ii. During the smart meter implementation period, the Concessionaire shall: provide the University with all information from the Concessionaire-installed smart meter readings, in a format prescribed by the University and in manner that allows the University to maintain, without interruption, the University's then-current internal system for usage recording and billing. The Concessionaire-installed smart meters must be read at consistent intervals and at least every 25 to 35 days, throughout the smart meter implementation period.
- b) As part of the Operations Plan, the Concessionaire shall include a plan to ensure metering accuracy and a metering accountability for such meters that are part of the steam portion of the Steam and Condensate System. For the avoidance of doubt, the Concessionaire shall adhere to all requirements set forth in Division 33 of the Design Standards, for flow, pressure, and temperature accuracy.
- c) The Concessionaire shall either continue to use the existing Instep System or use metering software of its choosing, subject to the Approval of the Annual Budget by the University. In either case, the Concessionaire shall provide the University reasonable access to view the real-time meter data upon request.
- d) The Concessionaire shall ensure electronic metering occurs at a minimum of one minute intervals.
- e) The Concessionaire shall maintain accurate software, monthly meter data, and billing.
- f) The Concessionaire shall ensure that all new building connections to the Steam and Condensate System are metered using networked smart meters meeting the specifications set forth in the Concession Agreement.
- g) Plant production meters
  - i. Production meters for the Steam and Condensate System must be in service when equipment is operating, functioning properly and reporting to a data system readily accessible by the University. If a primary production meter fails, the first meter downstream of the primary production meter shall be used. Failed primary meters must be replaced within 1 Business Day after such failure.
  - ii. Historical data on plant production meters shall be maintained in 1-minute intervals and readily accessible for the University's review. Raw 1-minute data shall be recorded in a database that cannot be edited by the Concessionaire. The Concessionaire shall allow the University to poll the 1-minute data daily via an "open database connectivity" connection for long term storage. Data will be time stamped with the date, hour (in 24 hr. format), and minute.

- iii. Meters shall be calibrated yearly and maintained in accordance with the manufacturer's recommendations. Calibrations shall be completed using a calibrator with a NIST traceable calibration certificate that is no more than 365 days old. The Concessionaire shall notify the University 3 Business Days in advance of meter calibration and allow the University to observe the calibration procedure. For PIC160/960, all 8 steam pressure transmitters must be calibrated yearly.

**5) Efficiency**

- a) The Concessionaire shall ensure that each boiler maintain a fuel factor of 1.41 mmBtu/mlb of exported steam measured at the boiler outlet.
- b) The Concessionaire shall ensure that the Steam and Condensate System has more than fifty (50) blowdown cycles, calculated based on measured concentrations.
- c) The Concessionaire shall ensure that the water recovery rate from the reverse osmosis treatment system is 75% or greater.
- d) The Concessionaire shall operate the Steam and Condensate System in a manner to ensure reliability as well as optimization of energy and conservation of natural resources. The Concessionaire shall use commercially reasonable efforts to continuously improve the operating efficiency and use of resources including water for the Steam and Condensate System.

**6) Design Standards**

- a) The Concessionaire shall maintain and keep up to date an accurate Steam and Condensate System hydraulic models, which may be KY Pipe or other similar modeling software, in order to:
  - i. Inform new buildings being connected to the Steam and Condensate System of the design pressure drop requirements based on system hydraulic models; and
  - ii. Verify and maintain system flow velocities.
- b) The Concessionaire shall adhere to the following pipe velocity limits for the Steam and Condensate System:
  - i. Existing piping headers and branches for the steam portion of the Steam and Condensate System to be limited to 180 and 220 fps respectively at peak flow;
  - ii. New piping headers and branches for the steam portion of the Steam and Condensate System to be installed at 150 and 200 fps respectively at peak flow;

- iii. Existing piping headers for the condensate portion of the Steam and Condensate System to be limited to 11 fps at 80% load;
  - iv. Existing condensate branch lines to be limited to 11 fps at 150% load;
  - v. New piping headers for the condensate portion of the Steam and Condensate System to be installed at 7.5 fps at 80% load; and
  - vi. New branch lines for the condensate portion of the Steam and Condensate System to be installed at 9 fps at 150% load.
- c) Steam distribution lines shall be located in a walkable Tunnel when paired with chilled water distribution lines and located in part of a main utility corridor, unless otherwise approved by the University in advance.
  - d) Steam distribution lines not located in a Tunnel shall be located in a trench box.
  - e) The Concessionaire shall follow the Utility Service Connection and Inspection Standard in set forth in Appendix H including the associated construction inspection matrix, and jurisdictional agreements with Ohio Division of Industrial Compliance.

## 7) **Unplanned Outage**

- a) An Unplanned Outage for the Steam and Condensate System shall mean the occurrence of one of the following:
  - i. Steam pressure at McCracken Power Plant is less than 100 psig for one-minute or more;
  - ii. Steam supply is interrupted to a building due to a closed or inoperable distribution valve, leakage, pipe failure, or other system failure;
  - iii. The Concessionaire fails to provide sufficient notice for such outage to be a Planned Outage;
  - iv. Tunnel vacuum is  $> -4''$  Hg for more than 10 minutes; or
  - v. The heating skid in the East Regional Chilled Water Plant is more than 5 degrees off set point for 60 minutes.
- b) The Concessionaire shall meet or improve upon historical averages for Unplanned Outages of the Steam and Condensate System including:
  - i. 10.3 Unplanned Outages per Fiscal Year; and
  - ii. 1178 lost customer connection hours (defined as duration of the outage, in hours, multiplied by the number of buildings affected by the outage) per Fiscal Year.

- c) If an Unplanned Outage of the Steam and Condensate System occurs, which causes a loss of service to a portion of the Utility System, the Concessionaire shall promptly and diligently, including 24-hour a day work, commence active work, regardless of potential delay by others, to correct the Unplanned Outage and restore service; unless otherwise approved by the University in its sole discretion.
- d) In the case of an Unplanned Outage of the Steam and Condensate System occurs, the Concessionaire shall notify Service2Facilities and provide updates every 60 minutes if the outage exceeds 60 minutes or more.

**8) Redundancy**

- a) Where possible, the Concessionaire shall maintain an N+1 level of redundancy for the Utility System Assets that make up the Steam and Condensate System. “N+1” is defined as the ability to meet seasonal peak load assuming the largest capacity Utility System Asset of the Steam and Condensate System is non-functional.
- b) If the Steam and Condensate System is below an N+1 level of redundancy, the Concessionaire shall promptly and diligently commence active work to correct the loss of system reliability within 48 hours.
- c) The Concessionaire shall ensure that at least two out of the three steam lines to the Medical Center are always in service.
- d) The Concessionaire shall maintain standby generators, or other backup equipment approved by the University, at Smith Substation and McCracken Power Plant with the ability to produce 6,100 kilowatts allocated to the Steam and Condensate System or the Chilled Water System, depending on seasonal requirements, or as directed by the University during a power outage. The University has the right to increase such requirement in its reasonable discretion, which shall be deemed a modification of these Performance Standards under Section 6.3(a) of the Concession Agreement.
- e) The Concessionaire shall perform biennial simulated black start testing of Smith Substation and McCracken Power Plant generators, South Campus Central Chiller Plant generators, and McCracken Power Plant process load shedding systems. The date and time of each test shall be discussed with the University representative and agreed upon no less than 30 days in advance of such test.
- f) The Concessionaire shall perform biennial simulated black start testing of McCracken Power Plant boilers on fuel oil, using propane and compressed air atomization for startup. The date and time of each test shall be discussed with the University representative and agreed upon no less than 30 days in advance of such test.
- g) Concessionaire shall include a chemical treatment plan for the Steam and Condensate System, as part of the Operations Plan. Such plan shall cover

frequency and validation of measurement and shall adhere to ASME boiler water quality standards.

- h) Concessionaire shall also include pretreatment standards as part of the Operations Plan, which shall include standards for:
  - i. Conductivity and hardness limits from water treatment plan; and
  - ii. Oxygen removal de-aerators.
- i) Amine or other chemical injection into the steam and condensate system shall not be allowed without express written consent of the University.
- j) Concessionaire shall adhere to American Society of Mechanical Engineers boiler water quality standards.

**9) Fuel Procurement, Operations and Storage**

- a) The Concessionaire shall maintain minimum on site storage of 430,000 gallons of fuel oil. The University has the right to increase or decrease such requirements in its reasonable discretion, which shall be deemed a modification of these Performance Standards.
  - i. Fuel oil shall have a sulfur content of less than 0.05% by weight, be premium diesel, ultra-low sulfur, suitable for use as either boiler or generator fuel.
  - ii. Each shipment of fuel oil received by the Concessionaire shall be sampled and analyzed for net and gross heat content in Btu/gal and Btu/lb by ASTM Method D4809, sulfur content in weight % by ASTM Method D4294, density in lb/gal and specific gravity by EPA Method D1298. Other methods may be acceptable if approved by the EPA. Records of analysis shall be maintained in accordance with University policy and applicable Law.
- b) The Concessionaire shall sample and analyze fuel oil in accordance with the requirements of all applicable environmental permits.

**10) Boiler water storage**

- a) The Concessionaire shall maintain minimum on-site storage of 80,000 gallons of treated water as an Emergency supply.

## **Part V - PERFORMANCE STANDARDS – ELECTRIC SYSTEM**

### **1) Power Requirements**

- a) Concessionaire shall ensure that the Electric System maintains:
  - i. Voltage: +6%/- 5% of nominal per American National Standards Institute (“ANSI”) C84.1- 1989 (or newer);
  - ii. Building transformer de-energized tap changers to deliver specified voltage;
  - iii. OSU Substation and Smith Substation transformer load tap changers shall deliver 7875 volts, with a variance of 70 volts on a 30-second time delay, as measured line to neutral;
  - iv. West Campus Substation transformer load tap changers shall deliver 7980 volts, with a variance of 70 volts on a 30-second time delay, as measured line to neutral; and
  - v. 0.95 minimum power factor at the substation buses.
- b) The Concessionaire shall operate and maintain the Electric System such that it is configured for building load and meets redundancy requirements as set forth herein.
- c) The Concessionaire shall operate and maintain the Electric System such that it meets the following power quality requirements:
  - i. For harmonic distortion, comply with IEEE 519 requirements; and
  - ii. For voltage sag or swell events, investigate any such event and minimize internal system disruption.

### **2) Line of Demarcation; Concessionaire, University, and AEP**

- a) Except as otherwise depicted in Appendix L and L1 (Campus Electrical System Single-Ended Sub Station and Campus Electrical System Double-Ended Sub Station), the line of demarcation for the Electric System shall be the secondary main breaker of the building service transformer including duct banks, manholes, and vaults and, where there is a double ended substation, the tie breaker will be included.
- b) Except as otherwise depicted in Appendix L and L1, the line of demarcation for the Electric System shall be up to the 138 kV air break switch on the American Electric Power, Inc. (“AEP”) side of the circuit switcher.



- i. AEP operates under an easement from the University and maintains its own equipment and the substation grounding mat.
  - ii. Sight perimeter walls, access and drainage systems and the SPCC Plan shall be included as part of the Electric System.
- c) The Concessionaire shall review and assume the current University role in complying with the operating, interlocking, and station service arrangements between the University and AEP outlined in, “Lines of Demarcation for the MV Distribution System” provided in Appendix L and L1.
- d) Where the physical line of demarcation within the Electric System is not set forth herein, or is not otherwise apparent, the line of demarcation shall be located on the low voltage side of the relevant building or structure transformer.

### **3) Metering**

- a) The Concessionaire shall purchase, install, maintain, and operate building electric smart meters in accordance with the requirements set forth in the Concession Agreement and as further outlined herein.
- i. The Concessionaire shall be responsible for operation and maintenance of any power quality support equipment within the Electric System and which is located outside of a University building.
  - ii. The Concessionaire shall ensure the meters are accurate and calibrated to the manufacturer’s recommendations.
  - iii. During the smart meter implementation period, the Concessionaire shall: provide the University with all information from the Concessionaire-installed smart meter readings, in a format prescribed by the University and in manner that allows the University to maintain, without interruption, the University’s then-current internal system for usage recording and billing. The Concessionaire-installed smart meters must be read at consistent intervals and at least every 25 to 35 days, throughout the smart meter implementation period.
  - iv. The Concessionaire shall provide to the University all information obtained from meter readings during the smart meter implementation period, in a format prescribed by the University.
- b) As part of the Operations Plan, Concessionaire shall include a plan to ensure metering accuracy and a metering accountability metric for such meters that are part of the Electric System. For the avoidance of doubt, the Concessionaire shall adhere to all requirements for metering and meter accuracy set forth in Appendix O, Division 337000 – Electrical Utilities Metering of the Design Standards.

- c) The Concessionaire shall either continue to use the existing Instep System or use metering software of its choosing, subject to the Approval of the Annual Budget by the University. In either case, the Concessionaire shall provide the University reasonable access to view the real-time meter data at its discretion. The current data uplink from the Schneider Electric SE licensed software program that the University uses to acquire, monitor and maintain electrical performance data for the electrical feeds within the Utility System (“ION System”) to the Instep System will be maintained by the Concessionaire.
- d) The Concessionaire shall ensure electronic metering occurs at a minimum of 1 minute intervals.
- e) The Concessionaire shall maintain accurate software, monthly meter data, and billing.
- f) The Concessionaire shall ensure that all future building connections to the Electric System are metered using networked smart meters meeting the specifications set forth in the Concession Agreement.
- g) Substation and campus feeder meters.
  - i. Main substation and campus electrical feeder meters that are part of the Electric System must be in service when equipment is operating, functioning properly and reporting to a data system accessible by the University. See Appendix S for a list of main substation and campus electrical feeder meters.
  - ii. Historical data on main substation and campus electrical feeder meters shall be maintained in 1 minute intervals and accessible for University review via a web client.
  - iii. Main substation and campus electrical feeder meters shall have event capture capability and store wave form level detail during periods of electrical disturbance.
  - iv. Meters shall be maintained in accordance with manufacturer’s recommendations and ANSI C12.20 class accuracy with bidirectional full four quadrant energy metering.

**4) Design Standards**

- a) The Concessionaire shall adhere to the University’s Design Standards and all legal requirements for the Electric System including but not limited to IEEE and NFPA.
- b) The Concessionaire shall follow the Primary Electrical Service Policy in Appendix M and associated construction inspection matrix and jurisdictional agreements with Ohio Division of Industrial Compliance.

- c) The Concessionaire is prohibited from installing, constructing or using above grade transmission and distribution lines.

**5) Unplanned Outage**

- a) An Unplanned Outage for the Electrical System shall mean the occurrence of one of the following:
  - i. A distribution feeder breaker, building transformer failure, primary fuse or primary switch opens and interrupts service to a building connected to the Electric System; or
  - ii. The Concessionaire fails to provide sufficient notice for such outage to be a Planned Outage.
- b) The Concessionaire shall meet or improve upon historical averages for Unplanned Outages of the Electric System including:
  - i. 6.84 Unscheduled Outages per Fiscal Year; and
  - ii. 98 lost customer connection hours (defined as duration of the outage in hours times the number of buildings affected by the outage).
- c) If an Unplanned Outage of the Electric System occurs which causes a loss of service, the Concessionaire shall promptly and diligently, including 24-hour a day work, commence active work to correct the Unplanned Outage and restore service, regardless of potential delay by others. Concessionaire shall restore service in accordance with the priority lists provided in Appendix R, as that list may be updated from time to time. Such updates shall be deemed a modification under Section 6.3(a) of the Concession Agreement.
- d) During an Unplanned Outages of the Electric System, the Concessionaire shall follow the Emergency Response and Switching plans provided in Appendix N.
- e) In the case of an Unplanned Outage of the Electric System, the Concessionaire shall notify Service2Facilities and provide updates every 60 minutes if the outage exceeds 60 minutes or more.
- f) The Concessionaire shall communicate with the University when it becomes aware of an AEP line or service feed that is out of service and is impacting any University facilities.

**6) Redundancy**

- a) Concessionaire shall operate the Electric System such that a single primary electrical power component outage shall result in a prolonged outage to no more than one service connection.

- b) Where possible, the Concessionaire shall maintain an N+1 level of redundancy for the Utility System Assets that make up the Electric System. “N+1” is defined as the ability to meet seasonal peak load assuming the largest capacity Utility System Asset of the Electric System is non-functional.
- c) If the Electric System is below an N+1 level of redundancy, the Concessionaire shall promptly and diligently commence active work to correct the loss of system reliability within 48 hours.
- d) Each component of the Electric System shall have at least one independent backup.
  - i. For each substation in the Electric System, maximum capacity shall be met with the loss of a single transformer or bus.
  - ii. For distribution feeders in the Electric System:
    - 1. Buildings must be assigned a normal and alternate feed; and
    - 2. Feeder loading shall be according to Electrical Design Guidance found in Appendix O.
  - iii. For building service substations in the Electric System, they shall be in a main-tie-main configuration for critical facilities such as hospitals, research facilities and larger stadiums and may be single-ended for non-critical facilities.
  - iv. For the following central utility plants, the Concessionaire must adhere to the redundancy requirements in Division 48 – Power Plant Electrical Utilities of the Design Standards:
    - 1. McCracken Power Plant;
    - 2. South Campus Central Chiller Plant;
    - 3. East Regional Chilled Water Plant;
    - 4. West Campus Substation;
    - 5. Water Plant;
    - 6. Smith Substation;
    - 7. OSU Substation; and
    - 8. Generator Plant.

**7) Distribution System Switching**

- a) The Concessionaire shall maintain circuit and equipment loading guidelines for the Electric System, as specified in the Electrical Design Guidance located in Appendix O.
- b) The Concessionaire shall provide switching for planned maintenance or construction outages for the Electric System. Switching shall result in no unplanned interruption to the University.
- c) Switch loading for the Electric System shall be done as required to comply with the following load limits:
  - i. Bus limits;
  - ii. Transformer load limits; and
  - iii. Feeder loading limits.
- d) The Concessionaire shall provide low voltage switching and support for building outages.
- e) As requested by the University for planning/design, for the duration of construction of new facilities on the Columbus Campus, the Concessionaire shall provide construction power and support which shall include;
  - i. Metering;
  - ii. Inspection of primary electrical service; and
  - iii. Other items described in the Primary Electrical Service Policy document referenced in Appendix M.

**Part VI - PERFORMANCE STANDARDS – NATURAL GAS SYSTEM**

**1) Natural Gas Quality**

- a) The Concessionaire shall ensure the Natural Gas System meets the following pressure requirements:

<u>NM#</u>	<u>System Description</u>	<u>psig</u>
2	Main Campus - 6 psig System	5
3	Main Campus - 18 psig System	18
4	South Medical Center System	17
5	Midwest System	20
6	Kenny Road System	6
7	Buckeye Village System	20
8	Carmack System (West)	2
9	Kinnear Road System	15
11	Don Scott System	2
12	Farm Science System	2

**2) Line of Demarcation; Concessionaire, University, and Columbia Gas**

- a) Except as otherwise depicted in Appendix L2 (Natural Gas Service), the line of demarcation for the Natural Gas System shall be the building envelope and the Natural Gas System shall include all natural gas building meters regardless of their location. Notwithstanding the above, the University retains the right to operate the building isolation valves for the purposes of conducting scheduled maintenance and as otherwise needed.
  - i. The Natural Gas System shall include the downstream side of the public utility master meter pressure regulator for natural gas feeds.
- b) Where the physical line of demarcation within the Natural Gas System is not set forth herein, or is not otherwise apparent, the line of demarcation shall be located within 2 feet of the interior of the relevant building or structure.

**3) Metering**

- a) The Concessionaire shall purchase, install, maintain, and operate natural gas smart meters for facilities connected to the Natural Gas System in accordance with the requirements set forth in the Concession Agreement and as further outlined herein. In addition, Concessionaire shall ensure that, any complex of University facilities served by Columbia Gas shall be sub-metered. Please refer to Appendix T for a list of existing natural gas master meters for the Natural Gas System.
  - i. The Concessionaire shall ensure the meters are accurate and calibrated to the manufacturer’s recommendations;

- ii. During the smart meter implementation period, the Concessionaire shall: provide the University with all information from the Concessionaire-installed smart meter readings, in a format prescribed by the University and in manner that allows the University to maintain, without interruption, the University's then-current internal system for usage recording and billing. The Concessionaire-installed smart meters must be read at consistent intervals and at least every 25 to 35 days, throughout the smart meter implementation period; and
  - iii. The Concessionaire shall provide to the University all information obtained from meter readings during the smart meter implementation period, in a format prescribed by the University.
- b) As part of the Operations Plan, Concessionaire shall include a plan to ensure metering accuracy and a metering accountability metric for such meters that are part of the Natural Gas System. For the avoidance of doubt, the Concessionaire shall adhere to all requirements set forth in the Design Standards for flow, pressure, and temperature accuracy.
  - c) The Concessionaire shall either continue to use the existing Instep System or use metering software of its choosing, subject to the Approval of the Annual Budget by the University. In either case, the Concessionaire shall provide the University reasonable access to view the real-time meter data at its discretion.
  - d) The Concessionaire shall maintain accurate software, monthly meter data, and billing.
  - e) The Concessionaire shall ensure that all future building connections to the Natural Gas System are metered using networked smart meters meeting the specifications set forth in the Concession Agreement.

**4) Design Standards**

- a) Except as otherwise set forth in the Concession Agreement the Concessionaire shall diligently continue the University's ongoing utility system project to relocate natural gas distribution piping outside of walkable Tunnels and branch Tunnels.
- b) The Concessionaire shall follow the Utility Service Connection and Inspection Standard in Appendix H and associated construction inspection matrix and jurisdictional agreements with Ohio Division of Industrial Compliance.

**5) Compliance with Public Utility Commission of Ohio ("PUCO") Regulations**

- a) For the Natural Gas System, the Concessionaire is required to comply with CFR part 191, 192 – *Transportation of Natural and other Gas by Pipeline: Minimum Federal Safety Standards*, as administered and enforced by PUCO.

- b) The Concessionaire shall update the Distribution Integrity Management Plan as require and as illustrated in Appendix P.
- c) The Concessionaire shall complete annual assessments of each master meter system and of the main gas line to the McCracken Power Plant and the gas line supplied from Godown Road. These assessments shall identify and address any correction action items and shall include the following items:
  - i. Line location;
  - ii. Comprehensive leak test with the following definitions, performed once a Fiscal Year by a third party:
    - 1. Class One leaks shall be immediately repaired;
    - 2. Class Two leaks shall be repaired within 12 months from the time the leak was reported; and
    - 3. Class Three leaks shall be monitored and rechecked not less than annually.
  - iii. Review of operating pressures against maximum allowable operating pressure;
  - iv. Inspection and test of district pressure regulators;
  - v. Inspection and service of key valves;
  - vi. Cathodic protection voltage testing and condition assessment to maintain required voltages;
  - vii. Odorant testing and verification;
  - viii. Review and update of Emergency Procedures for Natural Gas Operations and Public Awareness Program, contained therein (see Appendix N);
  - ix. Review and update of Natural Gas Operations and Maintenance Manual (see AppendixQ); and
  - x. Review and update of Natural Gas Distribution Integrity Management Plan (see AppendixP).
- d) The Concessionaire shall provide the University prompt notice of leak detection on any reported leaks or Emergency calls. Such activity shall be in addition to annual comprehensive leak tests performed by the Concessionaire.

**6) Unplanned / Unscheduled Outage**



- a) An Unplanned Outage for the Natural Gas System shall mean the occurrence of one of the following:
  - i. Natural gas supply is interrupted to a building due to a closed or inoperable distribution valve, leakage, pipe failure, or other system failure; or
  - ii. The Concessionaire fails to provide sufficient notice for such outage to be a Planned Outage.
- b) The Concessionaire shall meet or improve upon historical averages for Unplanned Outages of the Natural Gas System including:
  - i. 3.2 Unscheduled Outages per Fiscal Year; and
  - ii. 155 lost customer connection hours (defined as duration of the outage in hours times the number of buildings affected by the outage) per Fiscal Year.
- c) If an Unplanned Outage of the Natural Gas System occurs, which causes a loss of service to a portion of the Utility System, the Concessionaire shall promptly and diligently, including 24-hour a day work, commence active work, regardless of potential delay by others, to correct the Unplanned Outage and restore service.
- d) The Concessionaire shall promptly perform a leak test on areas of the Natural Gas System affected by such Unplanned Outage before restoring service to a building.
- e) In the case of an Unplanned Outage, the Concessionaire shall notify Service2Facilities and provide updates every 60 minutes if the outage exceeds 60 minutes or more.
- f) The Concessionaire shall communicate with the University when it becomes aware of a Columbia Gas line or service feed that is out of service.

**7) Redundancy**

- a) Where possible, the Concessionaire shall maintain an N+1 level of redundancy for the Master Meter 2 and Master Meter 3. “N+1” is defined as the ability to meet seasonal peak load with the largest capacity Utility System Asset of such non-functional meter. See Appendix T for description of Natural Gas Master Meters.
- b) If a loss of system redundancy occurs the Concessionaire shall immediately (after arriving at the location of the source of the problem in the time specified) and diligently commence active work to correct the loss of reliability within 48 hours.

## Part VII - PERFORMANCE STANDARDS – GEOTHERMAL SYSTEM

### 1) Temperature, Flow and Quality Requirements

- a) The Concessionaire shall ensure that the Geothermal System for which Concessionaire has full responsibility for Capital Improvements and O & M as described herein, delivers return water at 80 degrees F. during summer cooling operation. During winter heating operation, the Concessionaire shall continuously deliver water from the geothermal wellfield at any temperature but with a target temperature of 54 degrees F.
- b) The Concessionaire shall ensure that the Geothermal System delivers water to the University at 2600 gallons per minute (GPM).
- c) The Concessionaire shall maintain water quality in the Geothermal System as follows: Conductivity (mmhos): 0 min; Iron (Fe): at or below 1 ppm; and Nitrite (NO<sub>2</sub>): between 500-1000 ppm.

### 2) Line of Demarcation Between Concessionaire and University

- a) The line of demarcation for the Geothermal System is as set forth herein and is further depicted in Appendix L5 (Geothermal System – Cooling and Geothermal System-Heating). Appendix L5 serves as a representative diagram of the Geothermal System. Further information regarding the Concessionaire’s responsibilities for maintaining portions of the Geothermal System located in or connected to Tunnels, can be found in Appendix Z. For line of demarcation between the tunnel system and the utility piping system, see Appendix Z.
- b) Appendix L5 denotes those portions of the Geothermal System for which Concessionaire will have full responsibility for Operation and Maintenance (“O&M”) and for capital expenditures for upgrades and changes (“Capital Expenditures”) and those portions of the Geothermal System for which the Concessionaire will have responsibility for Capital Expenditures but the University will retain responsibility for the O&M (herein referred to as “Capital Only”). As depicted in Appendix L5, the Concessionaire’s responsibility for Capital Only in contrast to responsibility for Capital Expenditures and O&M is outlined as follows:
  - i. **Geothermal Heating System:** Concessionaire shall be responsible for Capital Expenditures and O&M for the geothermal well field and related distribution piping, up to and including, the isolation valves prior to the heat exchanger as well as for the supplemental steam and condensate distribution piping, up to and including, the heat exchanger meter assembly. The Concessionaire shall have Capital Only responsibility for the Geothermal System from the geothermal heat exchanger isolation valves to the building meter assemblies. The Concessionaire shall have Capital Only responsibility for the steam and heating hot water system from the heat exchanger meter assembly to the building meter assembly.

The Concessionaire shall Capital Expenditure and O&M responsibility for all of the building meter assemblies.

- ii. **Geothermal Cooling System:** The Concessionaire shall be responsible for Capital Expenditures and O&M for the geothermal well field and distribution piping up to and including the isolation valves prior to the heat exchanger. The Concessionaire shall have Capital Only responsibility for the Geothermal System from the geothermal heat exchanger isolation valves to the building meter assemblies. The Concessionaire shall have Capital Expenditure and O&M responsibility for all building meter assemblies.

### 3) **Metering**

- a) The Concessionaire shall purchase, install, and maintain networked smart meters for the Geothermal System meeting the specifications set forth in the Concession Agreement and as further outlined herein.
- b) Concessionaire shall ensure the meters are accurate and calibrated to the manufacturer's recommendations.
- c) As part of the Operations Plan, Concessionaire shall include a plan to ensure metering accuracy and a metering accountability metric for such meters that are part of the Geothermal System. For the avoidance of doubt, the Concessionaire shall follow guidelines set forth in Division 33 of the University's Design Standards for flow, pressure, and temperature accuracy.
- d) The Concessionaire shall either continue to use the existing Instep System or use metering software of its choosing, subject to the Approval by the University. In either case, the Concessionaire shall provide the University reasonable access to view the real-time meter data at its discretion.
- e) The Concessionaire shall maintain accurate software, monthly meter data, and billing.
- f) During the smart meter installation period, the Concessionaire shall provide the University with all information from the Concessionaire-installed smart meter readings, in a format prescribed by the University and in manner that allows the University to maintain, without interruption, the University's then-current internal system for usage recording and billing. The Concessionaire-installed smart meters must be read at consistent intervals and at least every 25 to 35 days, throughout the smart meter implementation period.
- g) The Concessionaire shall ensure that all future building connections to the Geothermal System are metered using networked smart meters meeting the specifications set forth in the Concession Agreement.

**4) Efficiency**

- a) When operating in cooling mode, the Concessionaire shall operate the Geothermal System more efficiently than the efficiency targets for the Chilled Water System, as defined in Part III, Section 5 herein.
- b) When operating in heating mode, the Concessionaire shall operate the Geothermal System with an average monthly efficiency equal to or more efficient than the average monthly efficiency from the 2 Fiscal Years prior to the Closing Date.
- c) The Concessionaire shall monitor the quality and chemically treat the Geothermal System well field loop water to maintain system efficiency (inclusive of flow, temperature and quality).

**5) Unplanned / Unscheduled Outage**

- a) An Unplanned Outage for the geothermal well field system shall mean the occurrence of one of the following:
  - i. The geothermal well field return temperature exceeds 85 degrees F. for more than 15 minutes or more, or 30 cumulative minutes in any 60 minute period, not including the first 15 minutes during initial startup;
  - ii. The geothermal well field loop pressure drops below 18 psifor 1 hour;
  - iii. The geothermal well field pumping system is unable to maintain the 2600 GPM set point for more than 15 minutes, or more than 30 cumulative minutes in any 60 minute period, not including the first 15 minutes during initial startup; or
  - iv. The Concessionaire fails to provide sufficient notice for such outage to be considered a Planned Outage.
- b) If there is a leak causing an Unplanned Outage of the geothermal well field, the Concessionaire shall promptly investigate, locate and repair such leak.
- c) Concessionaire shall notify the University if the well filed loop pressure drops below 18 psifor one hour or the makeup valve is open for more than 4 hours.
- d) If an Unplanned Outage of the Geothermal System occurs which causes a loss of service, the Concessionaire shall promptly and diligently, including 24-hour a day work, commence active work, regardless of potential delay by others, to correct the Unplanned Outage and restore service, unless otherwise approved by the University in its sole discretion.

**6) Redundancy**

- a) Where possible, the Concessionaire shall maintain an N+1 level of redundancy for the Utility System Assets that make up the Geothermal System. “N+1” is defined as the ability to meet seasonal peak load assuming the largest capacity Utility System Asset of the Geothermal System is non-functional. Maintaining N+1 redundancy does not include accounting for supplemental heating or cooling by using steam from the main campus distribution or cooling towers or any other comparable method in the future.
- b) If the Geothermal System is below an N+1 level of redundancy, the Concessionaire shall promptly and diligently commence active work to correct the loss of system reliability within 48 hours.

## LIST OF APPENDICES

- Appendix A - Standard Operating Procedures for Surveying and Utility Marking
- Appendix B - Emergency Support Function #12
- Appendix C - Utility Outage Procedures
- Appendix D - FOD Emergency Operation Plan
- Appendix E - Asbestos Abatement Scope of Work
- Appendix F - Design Standards
- Appendix G - Building Connection Basis of Design
- Appendix H - Utility Service Connection and Inspection Standards
- Appendix I - Legionella Exposure Control Plan
- Appendix J - Reserved
- Appendix K - Utility Maps
- Appendix K1 - Electric
- Appendix K2 - Natural Gas
- Appendix K3 - Chilled Water
- Appendix K4 - Steam and Condensate
- Appendix K5 - Geothermal
- Appendix L - Line of Demarcation
- Appendix L1 - Electric
- Appendix L2 - Natural Gas
- Appendix L3 - Chilled Water
- Appendix L4 - Steam and Condensate
- Appendix L5 - Geothermal
- Appendix L6 - Reserved
- Appendix M - Primary Electrical Service Policy
- Appendix N - Emergency Response and Switching Plan
- Appendix O - Electrical Design Guidance

- Appendix P - Natural Gas Distribution Integrity Management Plan
- Appendix Q - Natural Gas Operations and Maintenance Manual
- Appendix R - Restoration Priority List
- Appendix S - Main Substation and Campus Electrical Feeder Meters
- Appendix T - Natural Gas Master Meters
- Appendix U - Reserved
- Appendix V - Energy Conservation Measures Protocol
- Appendix W - Capital Improvements and Material Changes Protocol
- Appendix X - Communication Systems and Information Technology et or Protocol
- Appendix Y - Comprehensive University Public Way Management rotocol
- A e d u e l o t e rotocol a d Sta dard

## **Appendix A - Standard Operating Procedures for Surveying and Utility Marking**



# SOP

## Surveying Utility Marking

# SOP

Surveying

**THE OHIO STATE UNIVERSITY – FACILITIES OPERATIONS & DEVELOPMENT**

2013-03-11

## **1 Overview:**

Topographic and Utility surveys are conducted in an effort to support the Campus Mapping and GIS projects. While supporting Mapping and GIS is the primary focus, stored surveys also play a role in future design work for the University. To this extent, surveys are performed to accurately locate, inventory and catalogue all of the Universities assets both natural and manmade. While collecting the coordinate values of these assets, care should be taken to adequately capture attribute data about the same.

## **2 Organization:**

### **2.1 Equipment:**

This office utilizes various forms of survey equipment, most of which are kept in the surveying van or office, with the exception of the GPS. The GPS Base Station and radio are housed in a cabinet located in room 580M, Bevis Hall. The related antennas are mounted on the outside wall on the north side at the roof line.

### **2.2 Naming Surveys:**

No official naming convention exists for naming surveys themselves. However, each survey receives a unique ID when it is entered into the GIS data base. The naming convention is a simple alpha/numeric code (e.g. S-0001). The first character 'S' indicates survey and the four digit number is sequential, advancing one digit every time a new survey is created.

Typically surveys are named for what the survey is intended to represent. A utility survey will generally be named for the building or site where utilities are being installed. If a single utility is being installed, fixed or replaced then the abbreviation of the utility is the first part of the name followed by a short descriptor (e.g. EL Bricker). Topo surveys are named for the building or site, but the word "Topo" is added to the end.

### **2.3 Storing Surveys:**

Each survey is stored separately on the server. A folder containing the survey name is created in the GPS\_Surveys folder inside the folder named for the application where the survey is processed.

### **2.3 Archiving Surveys:**

Surveys are generally archived by the GIS department. The survey receives a prefix based on the application used to process the survey and is then moved to the Completed Surveys folder on the server under GPS\_Surveys.

## **3 Procedures:**

This office is charged with documenting construction and renovation changes that occur on the exterior of the campus buildings. We are required to survey anything that gets added or changed in, on or above the ground. These surveys are broken into utility and topographic surveys. Most generally utility surveys happen first, and capture everything that will eventually get buried. Once construction is complete, we then perform a topographic survey to capture the remaining elements.

### **3.1 Control Network:**

All control and survey observations are based on the Ohio State Plane Coordinate System, South Zone using the North American Datum of 1983 (1996) and the North American Vertical Datum of 1988, with all coordinates being given in feet.

### **3.2 Utility Surveys:**

Utility surveys are conducted as the utility is being installed (before it is backfilled) where possible. Types, sizes and configuration of the utility are recorded at this time. Every effort should be made to collect points where there is a vertical and/or horizontal change in grade, change in size, configuration, material, or at fittings. Points on utilities should be collected as described in sections 3.2.1 – 3.2.4. Points on utility structure are described in section 3.3.15.

#### **3.2.1 Pipes:**

Pipes are shot along the centerline at the top of the pipe. If points are collected at any other point they should be noted as such.

#### **3.2.2 Duct Banks:**

Ducts are shot along the centerline on the topmost conduit(s) prior to concrete being poured. After the concrete is poured shots can be taken along the centerline and noted as top of concrete (TC). Bottom of trench shots (BT) are also taken and can be collected in the center or along the sides of the duct.

### **3.2.3 Sewers:**

Sewers are treated like pipes, except inverts are taken in the structures. The structures rim and floor elevation is taken and the pipe inverts are referenced to the rim.

### **3.2.4 Vaults:**

All utility vaults are shot prior to backfill. The outermost edges/corners are shot, as-well-as the floor of the vault.

## **3.3 Topographic Surveys:**

Site Surveys should encompass all man-made and natural features. The features are listed, but are not limited to, those as described in sections 3.3.1 – 3.3.14.

All linear features need to have their beginning and ending points captured, as-well-as any horizontal and vertical changes in direction. Should a linear feature exist that does not have a change in direction, then intermediate points should be taken along its length at increments of no greater than 25'.

When performing a topographic survey every effort should be made to ascertain the presence of utility structures through a thorough visual inspection. A non-comprehensive list of generalized structure types and how they are to be located, based on symbol insertion points are described in section 3.3.15. Each entity may apply to more than one type of utility, and as such should be placed on the appropriate utility layer with the correct symbol.

### **3.3.1 Buildings:**

Structure – Building footprint as it touches the ground.

Overhang – Wherever possible overhanging roof structures and awnings should be captured.

Columns – Actual size and extents of columns should be captured as they touch the ground.

Window Wells – The extents and thickness of the structure should be captured and annotated as “window well” on a note layer.

Doors – The centerline locations of doors should be captured and noted along with the opening type (single door, double door, overhead door, etc.) on a note layer.

Loading Docks – The extents of the loading dock should be captured and labeled as “loading dock” on a note layer.

### **3.3.2 Walks:**

Boundary – The extents of all walkways should be captured except where the walk meets a surveyed curb, wall or other linear feature, then that feature will suffice as the boundary of the walk.

Material – Changes in material types should be noted and delineated. If no material type is noted then it will be assumed that the walk is of concrete construction.

Stairs – The extents of exterior stairways should be captured. Points should be collected at the top and bottom of each set of stairs, with the correct number of treads depicted between them on an average even spacing.

### **3.3.3 Curbs:**

Boundary – Points should be collected along the back of curb.

Curb Cuts – All curb cuts should be captured and annotated. Points should be captured at the top of the cut (at the curb) and the bottom of the cut (at the road surface).

### 3.3.4 Roads:

Boundary – For roadways that are not bounded by curbs, edge of pavement shots shall be taken.

Center Line – Roadway centerlines shall be captured.

### 3.3.5 Parking Lots:

Boundary – For parking lots not bounded by curbs, edge of pavement shots shall be taken.

Parking Spaces – See section 3.3.13.

### 3.3.6 Walls:

Boundary – The length and depth of walls shall be captured and depicted. Spot grades shall be captured along the top and bottom of walls and on both faces where applicable.

### 3.3.6 Plant Material:

Trees (individual) – The centerline locations of all individual trees shall be captured.

Tree Line (masses) – For wooded areas, a line depicting the canopy edge shall suffice, but shall be noted as “wooded area” on a note layer.

Plant beds – The perimeter of the bed should be captured except where the bed meets a surveyed curb, wall or other linear feature, then that feature will suffice as the boundary of the bed. Also, a note should be placed at the approximate center of the bed identifying it as a plant bed, and that note shall be placed on a note layer.

Tree Wells – The extents of the tree well shall be captured. When a curb type construction is used, the depth or width of the curb shall be captured as well.



### 3.3.7 Site Furniture:

Bike Racks – For lines of bike racks, the beginning and ending rack shall be shot along the centerline, with the correct number of remaining racks being placed between them on an average even spacing.

Benches – Centerline locations with an orientation.

Tables – Centerline locations with an orientation.

Kiosks – Centerline location.

Art/Sculpture – Points shall be collected depicting the extents of the object except for those objects less than five (5) feet in diameter, in which case a centerline location will suffice.

Flagpoles – Centerline location.

Bollards – Centerline location shall be captured and the material type noted (wood, metal, concrete).

Key Card Readers – Centerline location.

Traffic Gates – Centerline location of the control box.

Parking Meters – Centerline location of the post at the ground.

Concrete Pads – Extents.

Tree Grates – The size and extents of tree grates shall be captured.

Handrails – The beginning and end of the handrail shall be captured along with any change in direction.

Guardrails – Centerline locations of the posts to accurately depict the location and extents of the guardrail.

### 3.3.8 Fencing:

Chain Link – It is not necessary to capture every post, just the beginning and ending posts plus any change in direction. Gate post must be captured and the opening noted as “gate” on a note layer.

Post and Chain – It is not necessary to capture every post, just the beginning and ending posts plus any change in direction with the correct number of remaining posts being placed between the beginning and end on an average even spacing.

### **3.3.9 Athletic and Sports Fields:**

Grass – The extents of the field need to be captured along with any lines depicting the playing surface.

Hard Surface – The extents of the surface need to be captured along with any lines on the playing surface, and the surface type needs to be noted on a note layer.

### **3.3.10 Bridges:**

Boundary – Collect all points to define the bridge extents including abutment walls, columns, posts, piers, etc.

### **3.3.11 ADA Features:**

Curb Ramps – The centerline of the curb ramp, both top and bottom, are required for location and orientation.

Push Pads – Centerline location.

### **3.3.12 Water:**

Water Course – Centerline and width of intermediate water courses need to be captured. Where major water courses occur, capture the waterline at the bank.

Ponds – Capture the extents of the waterline at the bank.

### **3.3.13 Paint Markings:**

Parking Spaces – The beginning and ending spaces of a row of parking need to be captured with the correct number of remaining spaces being placed between the beginning and end on an average even spacing. Include the centerline marking where two rows of parking abut one another.

Crosswalks – Centerline points at the beginning and end on both sides defining the area of the crosswalk, diagonal striping is not required.

Stop Bars – Centerline points at the beginning and end.

Lane Markings – Along the centerline of the striping.

Arrow and Textural Indicators – Where noted on symbol sheet.

### **3.3.14 Signage:**

Plaques – Center of plaque.

Building Signs – Each end of the sign shall be captured at the posts.

Traffic Signs – Centerline of the post at the ground with the type noted on a note layer.

Street Signs – Centerline of the post at the ground.

Parking Signs – Centerline of the post at the ground with the type noted on a note layer.

### **3.3.15 Utility Structures:**

Manholes – Center of lid.

Junction Boxes – Center of lid.

Pull Boxes – Center of lid.

Utility Poles – Centerline location at the ground.

Switch Gear – Center of box.

Transformer – Center of box.

Exterior Outlets – Centerline of box for both ground and wall mounted items.

Concrete Pads – Extents of pad.

Light Poles – Centerline location.

Light Bollards – Centerline location.

Ground Lights – Center of fixture for flush mount and centerline for others.

Wall Lights – Centerline location at mounting height.

Emergency Phones – Centerline location.

Control Boxes – Center of box and the extents of the pad.

Valve Covers – Center of cover.

PIV's – Centerline location on the top of the valve.

Fire Hydrants – Centerline location.

Fire Dept. Connections – Centerline location and note number of connection points.

Siamese Connections – Centerline location and note number of connection points.

Meters – Centerline location.

Regulators – Centerline location.

Irrigation Heads – Center of head.

Cleanouts – Center of cover.

Catch Basin – Center of grate.

Curb Inlet – Center of structure at the curb line.

Downspouts – Centerline location at the ground.

Trench Drain – Both ends of grate.

Vents – Center of grate, or centerline of pipe.

Speakers – Centerline locations for both ground and wall mounted fixtures.

Fire Alarms – Centerline locations.

# SOP

## Utility Marking

**THE OHIO STATE UNIVERSITY – FACILITIES OPERATIONS & DEVELOPMENT**

2016-11-01

## **1 Overview:**

The Ohio State University owns and maintains all of its own utilities and as such is responsible for the marking of the same. The University is a member of the Ohio Utility Protection Service (OUPS) and receives marking request through this service. This office provides the marking service for all University owned utilities with the exception of Data Communication lines. The OCIO Infrastructure/TCN admin office has the responsibility of locating Data Communication lines. OCIO is also a member of OUPS. The University follows the guidelines set forth by OUPS. However, OUPS does not have color classifications for some types of University owned utilities (see 2.3 for further explanation).

## 2 Organization:

### 2.1 Equipment:

The main component for utility marking is the Metrotech 810 Line Tracer. The tracer, tracer accessories, shovels, manhole hook, etc. are stored in the survey van. The marking paint is stored in the van and in the paint locker located in the office.

### 2.2 OUPS Tickets/Marking Requests:

Marking requests are received from OUPS and have a 48 hour positive response deadline.

### 2.3 Paint Colors:

The following is a list of paint colors, and their respective utility(ies), used for locating and marking university owned utilities:

- Red – Electric (primary and secondary), Lighting
- Orange – Data Communications, Tunnels
- Yellow – Gas, Fuel Oil, Steam, Condensate
- Blue – Domestic Cold Water, Fire Lines, Domestic Hot Water, Heating Hot Water, Chilled Water, Irrigation
- Green – Sanitary Sewer, Storm Sewer
- Pink – Survey Markings



## 3 Procedures:

### 3.1 Verification:

Upon receipt of a new marking request call the requestor to verify project location and limits, time frame and utilities to be marked. Depending on the size of the area and the work being done, it is best to phase the markings staying one to two days ahead of excavation. Let the requestor know that OCIO is responsible for marking data communications.

### 3.2 Compile Existing Data:

Prior to locating utilities in the field it is imperative to have the most accurate existing data available. The following steps should ensure you have the appropriate information:

- Plot a 1:40 scale map of the area from the electronic Campus Quad maps.
- Check for any on-going or completed surveys in the area that have not been processed and integrated into the electronic maps.
- Check the Archives for areas or utilities that are questionable.
- If necessary, contact the appropriate shop for questions about specific utilities.

### 3.3 Field Work:

Use water based inverted tip spray paint when marking utilities. Flags should be used in conjunction with paint marks when requested or when snow, leaves or other such material would hinder the visibility or durability of the paint marks. The utilities should be marked with a dash every 20-25 feet. Symbology, pipe sizes and notes should be used to more clearly identify the utility:

- "E" – electric (not lighting and/or low voltage)
- "W" – water
- "G" – gas
- "IRR" – irrigation
- "SAN" – sanitary
- "SWR" – storm sewer
- "ABAN" – for known/verified abandoned utility line

Not all utilities are traceable. When a utility cannot be traced you may use one of the following methods:

- Stakeout the utility if it has been previously surveyed
- Scale from record plans
- Use divining rods.

Note, if any utility mark is questionable it is imperative that the requestor/excavator be notified of how the marks were placed on the ground.

# SOP

## APPENDIX

A – Surveying Codes

B – Resection

C – Unknown Control  
Points

D- Exporting from TBC  
to TSC2

E – Editing Control  
Points

## B Resection

1. From the data collector menu, select the measure icon.



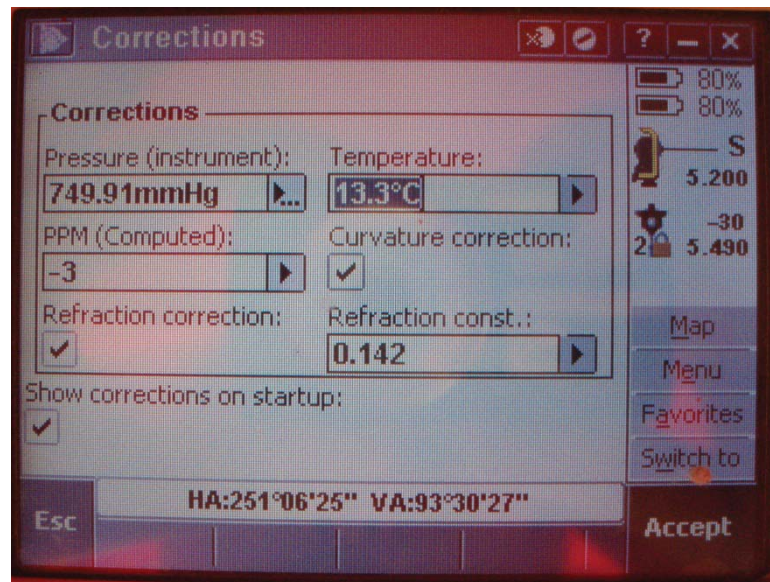
2. Select the current total station from the window.



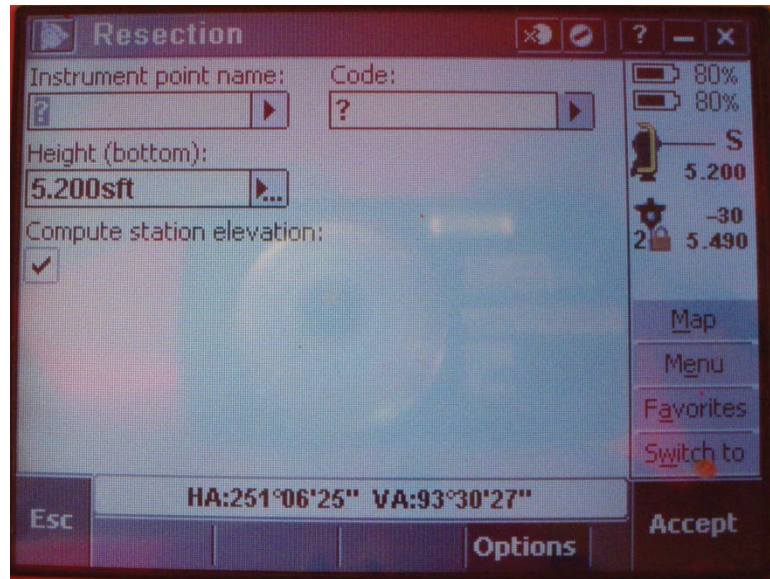
3. Select the "Resection" option from the popup window.



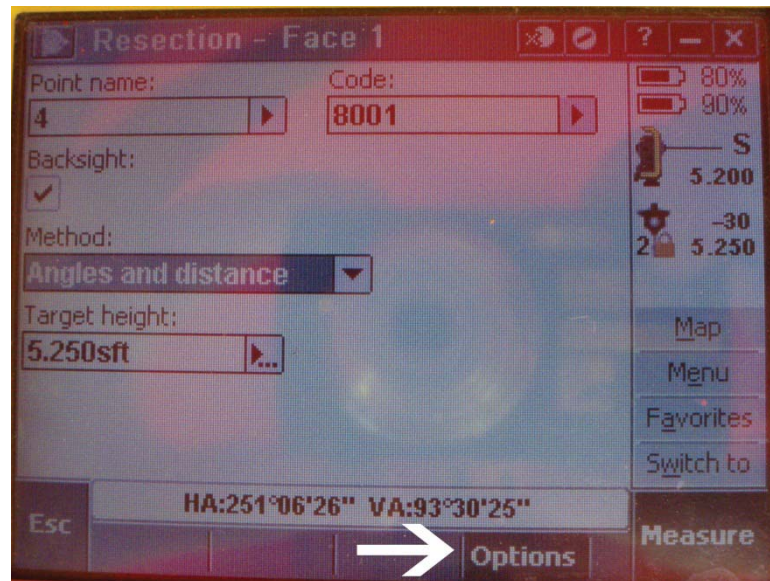
4. Enter the temperature and press "Accept"



5. Enter occupy point name, code and height and press “accept”



6. From the first point of the resection, select “options” at the bottom of the window

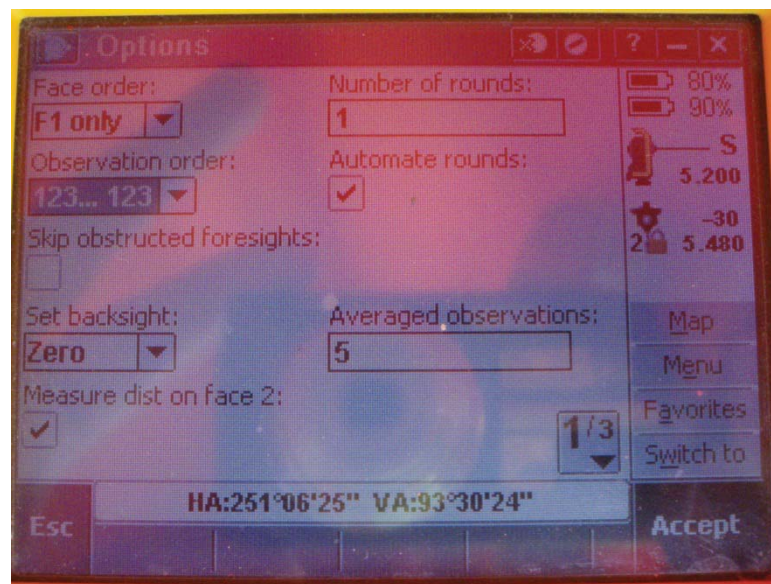


7. In options, make the following choices

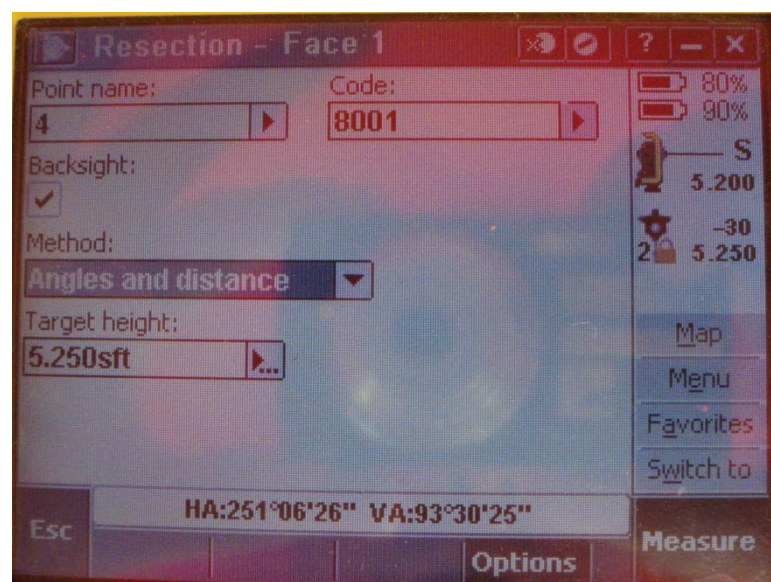
Change the "Face Order" to F1 or F1 and F2 depending on needs

Change number of rounds to desired

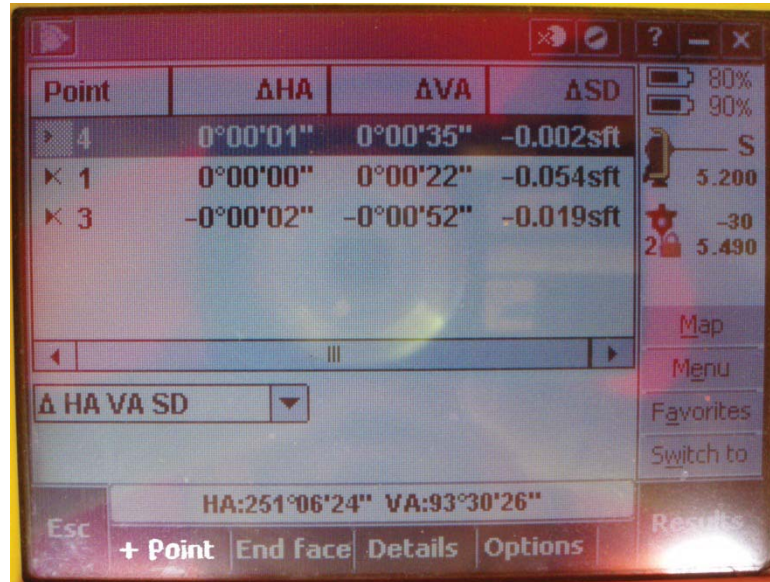
If using bipods or tripods with prisms over the backsight points, use the automated rounds feature to automatically allow the total station to perform the rounds for you with "Autolock." Automade rounds can still can be used when using the robotic prism and rod.



8. Enter the first point name and height and then measure the point.



9. Repeat step 8 for second point.
10. After two point, resection correction screen will appear. Continue to step 11 if only using two backsight points. At the bottom of screen select "+point" to add another backsight. Repeat step 8 and 10 for remaining backsight points.

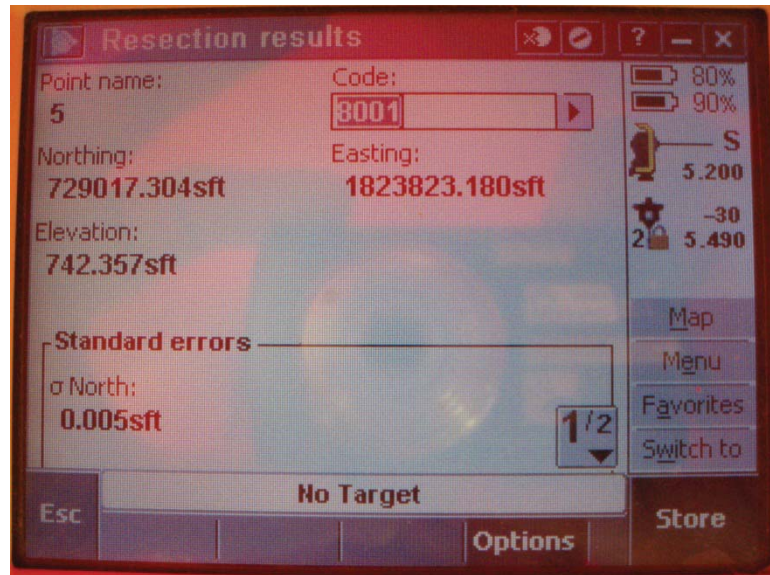


11. After reviewing residuals, if all are acceptable go to step 12. Highlight a point that has high residuals and click "details" to change what measurements to use (see figure above.) From the details screen, open the drop down menu to choose which measurements to use. Repeat for each point as necessary and press the "Results" button.





12. Store the point and start measuring topo points.



### Resection

1. Setup totalstation, select “Resection” from popup window instead of “Station Setup”
2. After the Instrument point screen, Select “Options” on the first point screen
3. Choose which face or faces to use and what order to perform the round or rounds
  - a. If using tripods over all backsight points, the robotic totalstation will turn the face and angle automatically after the first face is completed.
4. Measure the first two backsight points
5. From the correction screen, select “+point” at bottom of screen to add additional backsight(s)
6. Change the residuals to desired by highlighting the point and selecting “details” at the bottom of the window
  - a. In the drop done menu, change what measurements to use
7. When residuals are acceptable, store point
8. Start measuring points as normal

### C Unknown Control Points

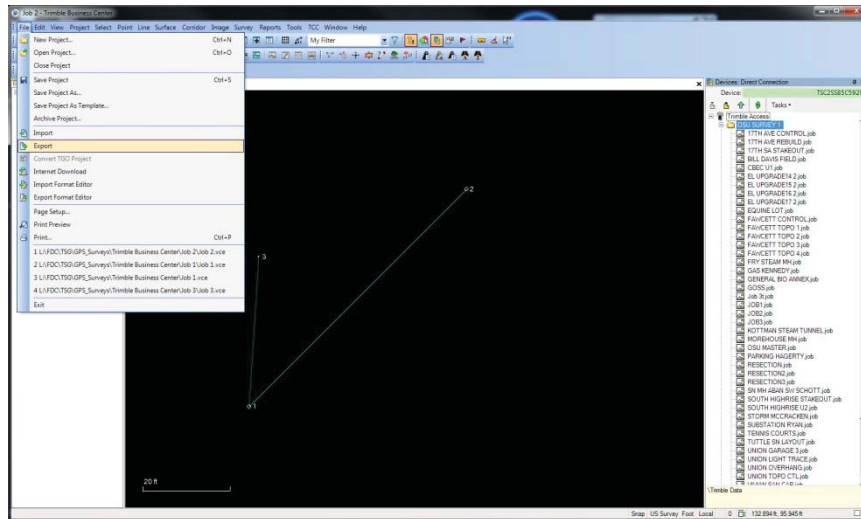
The following steps describe how to proceed with a survey using unknown control points. The unknown control point(s) can be the occupy, backsight or both, occupy and backsight.

1. Setup totalstation over occupy point as normal.
2. In the data collector, choose your occupy point, if the occupy point is known skip to step 4, if point is unknown continue to step 3.
3. If occupy point is unknown, choose an unused control point number leaving the code empty.
4. Make sure to fill out instrument height and proceed to the next step.
5. Select your backsight point, if the point is known skip to step 7, if point is unknown continue to step 6.
6. Choose the next available unused point, leaving the code empty
7. Measure the backsight and giving the azimuth an angle of 0°00'00”.
8. take survey shots as you normally would, taking care to enter the codes and rod height changes. Note, coordinates will not be calculated for surveyed points until the unknown point(s) have coordinates entered/shot and downloaded.
9. In the data collector, measure the unknown point(s) using the GPS or key in the point(s). When asked by the data collector on what to do with the duplicate point, select the **“STORE ANOTHER”** option from the drop down menu.
10. Copy the .job to the project folder for backup.
11. Download the data collector in Trimble Business Center (TBC). TBC will automatically calculate coordinates for all points shot with the unknown point(s).
12. Export job from TBC back to data collector (See Appendix D for exporting procedures.)

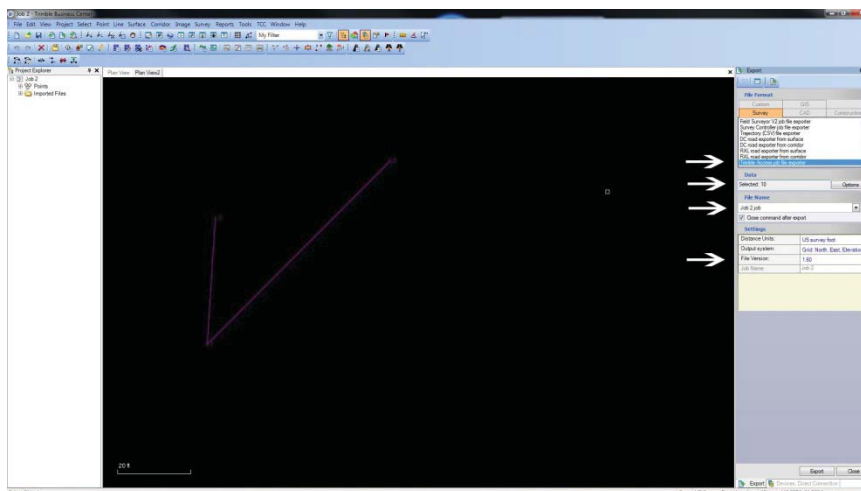
## D Exporting from TBC to TSC2

The following steps describe how to export a file from Trimble Business Center (TBC) to the TSC2 data collector.

1. Click on “File” tab and select “Export”



2. In the export window, make the following chooses.
  - a. File Format → “Survey” tab → Select “Trimble Access job file exporter”
  - b. Data, click on the options button and choose “Select All”
  - c. File Name, save file to computer (cannot transfer directly to date collector)
  - d. Settings should be set as follows:
    - i. US survey foot
    - ii. Grid: North, East, Elevation
    - iii. File Version : 1.60



3. Click on the “Export” button
4. Two files will be saved, delete the GEOID99(Conus).gff
5. Make sure original .job is saved in Project folder
6. Cut and paste the .job file to the data collector
7. Confirm and review .job file

### E Editing Control Points

The following steps describe how to change coordinates on a control point that had the wrong coordinates associated with the point.

1. In the data collector, measure the point(s) using the GPS or key in the point(s). When asked by the data collector on what to do with the duplicate point, select the **“STORE ANOTHER”** option from the drop down menu.
2. Copy the .job to the project folder for backup and write a .txt file explaining corrections of file for future inquiries.
3. Open a new file in Trimble Business Center (TBC) and drag the .job file from the data collector into the “plan view”.
4. Under the project explorer pane, open the point list.
5. Choose the point(s) that needed changed and delete the wrong coordinates under that point(s).
6. Press the “F4” key to have TBC recalculate the survey with the corrected points.
7. Proceed to export file as described in Appendix D. Depending on the situation, the user may want to export the job with a different name and then copy the corrected points into a new job file.

**Appendix B – Emergency Support Function #12**























## **Appendix C - Utility Outage Procedures**



## Procedures

The operations of The Ohio State University are dependent on reliable utilities. The requirements of these procedures ensure that appropriate actions are taken to minimize the impact of planned or unplanned utility outages to university operations.

## Definitions

1. Planned construction outage - A planned shutdown of a utility distribution system required for a building utility tie-in performed as part of a construction project under the direction of a project manager.
2. Planned utility repair outage - A planned shutdown of a utility distribution system to make repairs, performed as a maintenance activity under the direction of FOD Utilities.
3. Planned building outage - A planned shutdown of a building utility system to make repairs, performed as a maintenance activity under the direction of FOD Operations or Auxiliary Manager.
4. Declared emergency utility outage - An unplanned shutdown initiated by FOD Utilities to contain a pipeline leak or address an imminent electrical hazard.
5. Emergency utility outage - Unplanned loss of utility service because of a system failure.
6. Elevated risk of utility outage - A situation where back-up utility equipment or systems are out of service and normal redundancy is unavailable.
7. UTHVS - FOD Utilities High Voltage Shop.
8. UTSSD - FOD Utilities Support Services Distribution Shop.
9. S2F - Service2Facilities, 24-hour call center.
10. EOC - Emergency Operations Center.
11. ESF - Emergency Support Function.
12. Affected Party - Department or individual that is impacted by a utility outage.
13. Requestor - Utilities Outage Coordinator or person requesting the outage.
14. Zone Leader - FOD supervisor for the district/zone where the affected building(s) is located.
15. Auxiliary Manager - Manager that approves outages in non-FOD-managed facilities (i.e., Athletics, Medical Center, Student Life, etc.)
16. Utilities Planned Outage Notification email list - A contact list in the FOD email system to provide electronic notification of planned utility outages to university employees.
17. Utilities Emergency Outage Notification email list - A contact list in the FOD email system to provide electronic notification of emergency utility outages to university employees.
18. Medical Center Utility Notification email list - A contact list in the FOD email system to provide electronic notification of utility system outages or elevated risk of outages to Medical Center employees.

## Procedure Details

The following procedures provide detailed steps to coordinate planned utility outages and inform building occupants and facility managers of planned utility outages. Guidelines to communicate when there is an elevated risk of utility outages to the Medical Center are included. Emergency utility outage procedures contained herein cover basic communication steps only. Business continuity plans and emergency support functions (ESF) are independent of these procedures and provide the individual department and university guidelines for utility outages and other emergency situations that impact university operations.



## Procedures for a Planned Outage

### 1. Preplanning

- a. Person requesting the outage shall allow at least two weeks advance written or email notice to the Utilities Outage Coordinator for proper notification and preparation.
- b. If original requested outage is cancelled, an additional two-week request must be submitted for new date.
- c. Outage scheduling shall avoid home football games, commencement, conflicts with other scheduled outages or utility priorities, or other special events.
- d. Requesters should preview the Outage Calendar on FOD Outlook. Avoid requesting a mechanical outage on a day that already has a mechanical outage or other priority mechanical work scheduled. Avoid requesting an electrical outage on a day that already has an electrical outage or other priority electrical work scheduled.
- e. Outage requests shall include date, start and duration times, utility affected, work description, name and contact number for group performing the work. Requests for construction tie-in outages shall include the drawing sheet number.
- f. Person requesting the outage shall contact Utilities Outage Coordinator. For electrical outages, contact the FOD UTHVS Supervisor (Roger Music, 614-292-6273 office, 614-313-0217 cell). For all other outages, contact the FOD UTSSD Facilities Engineer (Becky Elliott, 614-688-1008) or Manager of Utilities Services (Jeff Mullins, 614-292-6383) and Operations Zone Leader or Auxiliary Manager to coordinate an outage. (See Utility Outage Notice Checklist for guidance.)
- g. The Outage Coordinator will schedule the outage as an appointment on the Outage calendar, shown as "tentative" to hold the date, subject to final confirmation and approval. Outage Coordinator will schedule the requestor as an attendee to the outage, and schedule Utilities support personnel and others as needed. Outage Appointment should be identified as either mechanical or electrical work.
- h. All affected parties shall discuss and reach understanding on the date and duration of planned outages. Required involvement will depend on outage type as follows:
  - i. Project manager involvement is required for construction scheduling and premium time approval.
  - ii. Utilities involvement is required for agreement on scheduling for switching and/or valve operation necessary for utility isolation. Pre-planning shall consider the potential for isolation valve leak-through and whether a test outage is required.
  - iii. Zone Leader or Auxiliary Manager is required for building system input and pre-outage preparations when building systems are impacted.
  - iv. Building coordinator and/or building occupants required for input on building program and/or occupant computer system impacts.
  - v. Electrical outage dates will be discussed with building occupants and proposed outage dates issued to addressees on the utility outage email lists for additional input.
  - vi. ULAR contact required for buildings housing ULAR facilities
  - vii. Medical Center Engineer required for all utility outages affecting Medical Center facilities. Contact Wexner Medical Center Facility Services Engineering Department (614-293-8244 or 614-293-8885).
  - viii. Domestic Water outages that impact Fire Protection Systems and result in sprinklers or fire pumps out of service for more than 8 hours require review and notification of insurance carrier through the Office of Risk Management.
  - ix. Department of Public Safety, Emergency Management and Fire Prevention shall be notified of any outages that impact Building and Site Fire Protection Systems.
- i. FOD Utilities will determine the required distribution system isolation points and how many buildings are affected.
- j. Zone leaders assist with customer communications, determining building system impacts, and that the time and the date of the outage are reasonable for building occupants.



- k. Utilities Outage Coordinator or person requesting the outage will complete the Utility Outage Notice and obtain two required signatures from:
    - i. Utilities Sr. Director (Ross Parkman), *OR* Manager of Utility Services (Jeff Mullins), *OR* Utilities Technical Director (Ryan Wester), *OR* Electrical Engineer (Jim Anderson)  
*AND*
    - ii. Operations District Leaders (Kenny King or Darlene Gluck)  
*OR*
    - iii. Auxiliary Managers: Athletics – Assoc. Director (Donald Patko), Student Life – Systems Manager (Daniel Hausman), or Medical Center (Chad Keltner), etc.
  - l. Once the outage has been approved by affected parties, the Outage Coordinator will change status of appointment from “tentative” to “busy” to indicate acceptance and confirmation of the outage dates on the Outage Calendar and send an appointment update to the attendees.
2. Notification (Utility Outage Notice Checklist)
- a. Copy of completed Utility Outage Notice to be forwarded by the requestor to Utilities and posted in the Utilities office area by 060 Central Service Building.
  - b. Outage notices shall be posted at all entrances to the building when the date is confirmed. Target at least three days before the outage.
    - i. 13,200 volt electric outage notices will be posted by FOD UTHVS Supervisor (Roger Music).
    - ii. Steam, water, or gas distribution system outage notices shall be posted by the person requesting the outage.
    - iii. All other outage notices shall be posted by the person requesting outage.
  - c. Electronic notifications (Outlook Global Address List):
    - i. Electronic notifications will be sent to the Utilities Planned Outage Notification email list.
    - ii. For outages impacting the Medical Center or BRT, use the Medical Center Utility Notification email list.
    - iii. Post the notice to the Building Coordinator listserv by requestor.
  - d. Telephone notification by requestor, if needed
    - i. OCIO at 614-292-8648 (for electrical outages only)
    - ii. Classroom scheduling at 614-247-1694
    - iii. S2F at 614-292-HELP.
    - iv. Office of Risk Management at 614-247-8840 (for domestic water outages to Fire Protection/Sprinkler Systems lasting more than 8 hours only)
    - v. Department of Public Safety, Emergency Management at 614-247-4911 or Fire Prevention at 614-247-3473 (for water or electrical outages that impact Fire Protection Systems).

### **Elevated Risk of Utility Outage for Medical Facilities**

1. When redundant utility service equipment or systems supplying Medical Center Facilities are taken out of service for maintenance or construction activities, there is an elevated risk of utility outage impact to patient care.
2. Because of accreditation requirements, FOD Utilities shall notify Medical Center personnel, via the Medical Center Utility Notification email list, when outages are planned to normal utility back-up systems. Medical Center personnel shall evaluate the elevated risk and initiate contingency planning per their internal procedures.



## Fire Hydrant Outages

1. All fire hydrants that are rendered inactive because of a domestic water outage shall be either tagged with an “Out of Service” ring or bagged with a black commercial plastic bag taped to the affected hydrant.
2. Notify Department of Public Safety Emergency Management at 614-247-4911 and Fire Prevention at 614-247-3473 of any fire hydrant outages.

## Communication Procedures for an Emergency Outage

1. Declared emergency utility outages should follow the planned outage procedure as closely as possible to notify building facility managers and occupants. Timelines will be condensed, and posting of outage notices may not be possible. Utilities will communicate with Medical Center Building Operations as appropriate.
2. Building occupants experiencing an emergency utility outage shall call S2F at 614-292-HELP. S2F shall then notify appropriate responders in Utilities, Operations, or Student Life. S2F shall provide additional notifications as specified in S2F procedures.
3. Medical facilities personnel experiencing an emergency utility outage shall notify Medical Center Facilities Dispatch at 614-293-8645 or Medical Center Security at 614-293-8500. Medical Center Facilities personnel shall then notify FOD Utilities counterparts directly as needed or S2F as back-up.
4. FOD personnel shall contact S2F with information on unplanned or emergency outages (and the Medical Center Security Control Center at 614-293-8500 when the outage affects the Medical Center).
5. FOD Utilities shall provide email notification using the Utilities Emergency Notification email list as soon as possible following a widespread emergency utility service outage with periodic follow-up notifications.
6. Notify the Office of Risk Management at 614-247-4911 if domestic water outages to Fire Protection/Sprinkler Systems last more than 8 hours.
7. For emergency utility outages, complete a Utility Outage Emergency Notice Report.
8. The Utilities outage coordinator shall enter outage details in the outage tracking database.

## Associated Responsibilities

1. Project Managers shall ensure that project funding includes construction contingency and that construction project specifications and drawings address utility tie-ins, construction risk mitigation measures, and premium time outage scheduling that could impact bid pricing.
2. University functions, departments, colleges shall implement individual business continuity plans when appropriate because of emergency utility outages.
3. The Department of Public Safety and university leadership shall evaluate unplanned utility outages and activate the EOC and subsequent ESFs when necessary.
4. Medical Center Facilities Services and Medical Center Safety will evaluate outages and activate the Medical Center Incident Command Center when necessary.
5. University managers shall coordinate updates to the email notification lists with FOD Utilities. Three email lists are maintained. There are two email lists for planned outages (campus and Medical Center) and one email list for widespread utility emergency notices. FOD Utilities will request that OCIO update the Medical Center notification list.

## **Appendix D – FOD Emergency Operation Plan**



















































































































## **Appendix E – Asbestos Abatement Scope of Work**

I. Statement of Work:

The Ohio State University and Wexner Medical Center desire to have a complete program of Asbestos Abatement Class I, II, III and IV work including but not limited to:

- A. *Class I Asbestos Work* – activities involving the removal of thermal systems insulation (TSI) and surfacing asbestos containing material (ACM) and presumed ACM (PACM). Asbestos abatement workers certified for Class I work also may perform other asbestos operations, such as the removal, repair, and maintenance of wallboard, floor tiles, mastics, roofing, etc.
- B. *Class II Asbestos Work* – is activity involving the removal of ACM that is not thermal system insulation or surfacing material. This includes, but is not limited to, the removal of asbestos containing wallboard, floor tile and sheeting, roofing and siding, and construction mastics.
- C. *Class III Asbestos Work* – is repair and maintenance operations, where ACM, including thermal systems insulation and surfacing ACM and PACM, is likely to be disturbed.
- D. *Class IV Asbestos Work* – is maintenance and custodial activities during which employees contact but do not disturb ACM or PACM and activities to clean up dust, waste, and debris resulting from Class I, II, and III activities.

The Ohio State University and Wexner Medical Center require service providers of proven quality, and only state licensed contractors will be accepted.

II. Scope of Work:

The Contractor must provide standardized ACM management throughout all University and Medical Center facilities. The Contractor must assist the University to properly manage:

- A. In place ACM and abate ACM and PACM;
- B. The release of asbestos fibers until ACM is scheduled for removal;
- C. The response to emergency repairs;
- D. Corrective measures when asbestos hazards are encountered.
- E. Re-installation of building materials as requested i.e. insulation, drywall etc.

Asbestos must be safely managed in place, nuisances corrected, and danger to human health and the environment must be reduced or eliminated.

III. General Contract Requirements:

- A. The Contractor must maintain regulatory guidance documentation based upon applicable state and federal regulations.
- B. The Contractor must provide for personal protective equipment (PPE) selection and mandated training for all abatement workers.
- C. The Contractor shall comply with all applicable university, state, and federal reporting and recordkeeping requirements, which includes and not limited to those referenced in Section XVII Document and Recordkeeping.

- D. The Contractor must protect the health and safety of university staff during asbestos abatement activities through established state and federal regulations.
- E. The Contractor must assure contract employees practice safe work procedures, use the proper equipment and control measures, and follow appropriate rules and regulations in accordance with their training.
- F. The Contractor must maintain records as to the quantities of the abated ACM and employee asbestos work exposures.
- G. The Contractor must respond to provide 24 hour emergency response service and be able to commence emergency repairs within 2 hours of initial contact.
- H. The Contractor must provide input on best practices, new technologies, etc. on abatement.
- I. Proposals/quotes for individual projects must be submitted to the appropriate project manager within 5 business days from the initial request.
- J. Final project project notifications shall be submitted to OSU within 30 days of abatement completion.
- K. Contractor shall provide a summary of any EPA violations in the past 5 years.
- L. Contractor shall provide a summary of ODH violations in the past 5 years.
- M. Contractor shall provide a summary of OSHA violation in the past 5 years.

IV. Applicable Standards:

- A. Asbestos for General Industry: Occupational Safety and Health Administration (OSHA) 29 CFR 1910.1001
- B. Asbestos Standards for Construction: OSHA 29 CFR 1926.1101
- C. National Emissions Standards for Hazardous Air Pollutants (NESHAPS): 40 CFR 61, Subpart M (National Emission Standard for Asbestos)
- D. Asbestos Model Accreditation Plan (MAP): 40 CFR 763 (Appendix C)
- E. Ohio Department of Health Asbestos (ODH) Regulations – Ohio Revised Code (ORC), Chapter 3710
- F. Ohio EPA Asbestos Regulations – ORC, Chapter 3745

V. Types of Abatement Methods to be performed (not limited to):

- A. Glove bag Removal, including high temperature abatement projects (150 to 600 degrees F)
- B. Repair, Patching, Sealing, and Removal of Damaged Thermal System Insulation (TSI)
- C. Decontamination: Damaged Asbestos
- D. Resilient Flooring and Adhesive Removal
- E. Floor Penetrations

- F. Mastic (floor, ceiling, wall), cutting, drilling and minor repairs
- G. Drywall cutting, drilling, and minor repair
- H. Plaster cutting, drilling, and minor repair
- I. Fireproofing
- J. Roofing
- K. Tran site
- L. Caulk/Glazing
- M. Abatement within full containment per state and federal regulations

VI. Regulated Area:

All Class I through III work must be conducted within a regulated area. A regulated area must:

- A. Be demarcated in a manner to restrict persons from entering and protect from exposure to airborne asbestos.
- B. Have signs posted.
- C. Require the use of respirators, if necessary, prior to entry.
- D. Not allow Contractors to eat, drink, smoke, chew tobacco or gum, or apply cosmetics.
- E. Be supervised by a competent person.

VII. Contractor Requirements:

- A. The Contractor must have the appropriate State License.
- B. The Contractor's employees must have an Asbestos Abatement Worker License.
- C. The Contractor must have an Asbestos Hazard Evaluation Specialist License.
- D. The Contractor must have an Asbestos Hazard Abatement Specialist License.

VIII. Contractor Regulatory Oversight:

The Abatement Contractor must provide internal oversight of all abatement activities. Oversight must be demonstrated by self-auditing through a documented quality assurance program, and other quality control measures to ensure abatement activities are performed in accordance with applicable regulatory standards and requirements. Abatement contractor must provide quality assurance information and make pertinent records available to OSU's designated asbestos abatement coordinator, Environmental Health and Safety (EHS) and/or external third party oversight personnel when requested.

IX. External oversight:

OSU reserves the right to hire a third party to insure abatement activities meet regulatory requirements. The Contractor must provide information and make pertinent records available to the third party, designated asbestos abatement coordinator, and EHS.

X. OSU Coordination:

The contractor must coordinate the work with the designated asbestos abatement coordinator. Coordination includes but is not limited to: meetings to discuss the work to be performed, schedule and timing of work, progress updates, and visual inspection throughout and upon completion of the requested work.

Projects that require space for Contractor supplied decon/shower transition from containment area to clean area must be reviewed and approved by designated asbestos abatement coordinator.

Asbestos abatement coordinators and/or EHS may monitor work on behalf of OSU. Monitoring includes, but is not limited to; placarding and securing of the abatement area, checking that asbestos waste is being properly packaged, labeled, and secured, and assessing work practices and the quality of asbestos removal.

The designated asbestos abatement coordinator has the right, per the terms and conditions of the contract, to stop the contractors work progress at any time during the project.

The EHS department at the University is the liaison for local, county, and state agencies regarding asbestos issues and inspections.

XI. Agency Notification:

The contractor must make all agency notifications required by EPA and ODH regulations. Abatement activities that exceed the ODH limit of 50 linear or 50 square feet, and/or the Ohio EPA's limit of 160 linear feet or 260 square feet require the Contractor to make 10 day advance notification to the appropriate state agency or agencies.

XII. Owner Notification:

All Building/Area Occupants within and adjacent to the area in which asbestos abatement work is to be performed must be notified as follows:

- A. The Contractor must immediately notify the designated asbestos abatement coordinator about the work schedule.
- B. The designated asbestos abatement coordinator must be notified of all activities that affect ACM and PACM in occupied areas.
- C. The designated asbestos abatement coordinator will notify the appropriate University representative (e.g. building coordinator, facility manager).
- D. The Contractor must notify EHS via email using the Asbestos Abatement Notification form (Exhibit 1).

XIII. Asbestos Waste Handling, Pickup, and Disposal:

The Contractor is to arrange for a pickup and disposal of all ACM or PACM material to an EPA licensed disposal site. Contractor supplied lockable containers may be located on owner property at the approval of the owner.

The contractor shall generate waste manifests, which shall be signed and returned to the designated asbestos abatement coordinator as per applicable regulations.

XIV. Monitoring:

A. Personal Exposure Air Monitoring:

Contractor must perform personal exposure air monitoring of abatement workers per NIOSH Sampling method 7400. Personal exposure air sampling must adhere to the OSHA Asbestos Standards (29CFR1926.1101; 29CFR1910.1001). Personal exposure air monitoring for both 8-hour Time Weighted Average (TWA) and 30-minute short term exposure must be conducted following OSHA regulations.

B. Environmental Monitoring:

Initial, interim, and final environmental air monitoring may be requested by the designated asbestos abatement coordinator as an additional service.

C. Air Clearance Monitoring:

Full containment negative pressure enclosures will require visual assessment and PCM final air clearance monitoring.

XV. Sample Analysis:

Initial, interim, and final air samples must be analyzed by Phase Contrast Microscopy (PCM). The samples may be analyzed by Transmission Electron Microscopy (TEM) if more definitive data is desired by the designated asbestos abatement coordinator as an additional service. Analysis of air samples must be the responsibility of the Contractor and must be performed by a certified technician and accredited laboratory using applicable regulatory protocols. The certified technician and accredited laboratory must have a documented quality control and quality assurance program for samples. The certified technician and accredited laboratory must provide sample analysis within 24 hours.

XVI. Safety Precautions:

The asbestos abatement contractor is responsible for all required safety precautions performed in environments that pose other hazards, including but not limited to; confined spaces, energized sources, and thermal stress.

XVII. Documentation and Recordkeeping:

Contractor must provide, prior to invoicing, close out documentation to the designated asbestos abatement coordinator and to EHS including but not limited to; employee sign in sheets, interim tracking documents, job logs, air samples, data sheets, air test results, waste shipment records from landfill for each job.

Exhibit 1 – EHS Asbestos Abatement Notification Form

**ASBESTOS HAZARD ABATEMENT PROJECT NOTIFICATION**

This document shall be submitted electronically (contact information provided below) prior to five (5) business days of any Asbestos Abatement Project conducted at The Ohio State University (OSU). Note that this document does not serve as an Asbestos Hazard Abatement Project Agreement, as required by the Ohio Department of Health (ODH) Ohio Administrative Code Chapter 3701-34-11. Furthermore, OSU requires that all Asbestos Abatement Contractors complete and provide an Asbestos Hazard Project Agreement when performing any asbestos abatement projects at OSU, regardless of size and/ or magnitude.

Notification Goes to:	Responsibility	E-mail	Phone
David Kehl	Environmental Safety Officer	<a href="mailto:kehl.1@osu.edu">kehl.1@osu.edu</a>	(614) 292-1284; ext. 4-6838
Ryan Malott	Hazardous Material Coordinator	<a href="mailto:malott.2@osu.edu">malott.2@osu.edu</a>	(614) 292-6747
Keith Shockley	Assist. Director, Operations	<a href="mailto:shockley.5@osu.edu">shockley.5@osu.edu</a>	(614) 292-5827
Kurt Keaton	Ren. & Const. Project Coordinator	<a href="mailto:keaton.19@osu.edu">keaton.19@osu.edu</a>	(614) 292-4296
Michael Rowley	Project Coordinator	<a href="mailto:rowley.48@osu.edu">rowley.48@osu.edu</a>	(614) 247-1507

Original       Revision       Revision number \_\_\_\_\_

**GENERAL PROJECT INFORMATION**

Date: \_\_\_\_\_ Abatement Contractor: \_\_\_\_\_

Name of Project: \_\_\_\_\_ OSU Project Number/ PO: \_\_\_\_\_

Project Dates/ Hours of Work: \_\_\_\_\_

Building Name/ Address: \_\_\_\_\_

General Location of Work: \_\_\_\_\_

OSU Contact Name / Phone / E-mail: \_\_\_\_\_

Has ODH been notified of this project? Yes  No       Has Ohio EPA been notified of this project? Yes  No

Name of AHES surveyor/inspector: \_\_\_\_\_

**ASBESTOS ABATEMENT PROJECT DESIGN**

Does this project involve the abatement of at least 50 sf or 50 lf of friable ACM? Yes  No

Has an asbestos project design been prepared for this project in compliance with OAC 3701-34-09 for projects over 50 sf / 50 lf? Yes  No

Has an asbestos project work plan been prepared for projects less 50 sf / 50 lf? Yes  No

Have third-party technical specifications been prepared for this project? Yes  No

Identify ODH Asbestos Project Designer who has prepared the abatement project design or person who prepared work plan:

Name	Company	ODH License Number	Expiration Date

If this project is not publically bid, or the public bid does not include an abatement project design, electronically submit the project design as an attachment to this notification.



**ASBESTOS ABATEMENT SCOPE OF WORK**

The following summarizes the description of the project and associated activities, quantities of asbestos containing materials (ACM) to be abated, exact location and type of materials to be abated, and containment / engineering controls/ work practices to be utilized:

**Work Area:** \_\_\_\_\_ **(General Description)**

<b>Building Specific Location(s)</b>	<b>Type of ACM</b>	<b>Quantity of ACM (sf or lf)</b>	<b>Engineering Control(s) (Insert Applicable Numbers Below)</b>

Notes (Use for Engineering Controls): (1) Full Negative Pressure Containment; (2) Negative-pressure Glovebag; (3) Wrap and Cut; (4) Negative Pressure Mini-Enclosure; (5) Regulated Area; (6) Three-stage Decontamination Chamber with Hot and Cold Water; (7) Critical Barriers; (8) Primary 6-mil Polyethylene Barriers; (9) Secondary 6-mil Polyethylene Barriers; (10) Polyethylene Drop Cloths; (11) Air-Filtration Devices Exhausted to Exterior of Building; (12) HEPA Vacuums (13) Wet Methods of Removal with Amended Water; (14) Encapsulation; (15) Other (Please specify)

\*\*\*\*\*For additional space needed space to add more work areas, please reference Page 4.

**PROJECT SUPERINTENDENT AND WORKER CERTIFICATIONS and SUBMITTALS**

The following employees are anticipated to be working on the project. Should any other additional personnel perform work upon initiation of the project, then the contractor shall provide updated submittal information for these employees as personnel changes occur. The below list summarizes the employee names, dates of expiration for ODH licenses, EPA training certificates, medical surveillance, and fit testing (half-mask / PAPR):

<b>Supervisor Name</b>	<b>ODH Card No./ Exp. Date</b>	<b>Training Cert. Exp. Date</b>	<b>Medical Exp. Date</b>	<b>Half Face Fit Test Exp. Date</b>	<b>PAPR Fit Test Exp. Date</b>
<b>Worker Name</b>	<b>ODH Card No./ Exp. Date</b>	<b>Training Cert. Exp. Date</b>	<b>Medical Exp. Date</b>	<b>Half Face Fit Test Exp. Date</b>	<b>PAPR Fit Test Exp. Date</b>

The Contractor certifies that all persons working on the project are currently licensed or certified by ODH.

\*\*\*\*\*For additional space needed to add more employees, please reference Page 5.

**CLEARANCE TESTING**

Final air clearance testing will be performed on this project in each containment / regulated area: Yes  No

When final air clearance sampling is performed, the following type of sampling will be used: PCM  TEM

If no clearance sampling is planned to be conducted, please provide a detailed explanation / comments as to why:

---

When final air clearance sampling is conducted, the contractor will assure that all clearance air sampling for each sampling episode is conducted by an ODH Certified Asbestos Hazard Abatement Monitoring Technician, or ODH Certified Asbestos Hazard Evaluation Specialist, or a Certified Industrial Hygienist (CIH) or Industrial Hygienist in Training as Certified by the American Board of Industrial Hygiene (ABIH).

Identify the person below who is performing the final visual inspection and final clearance air-testing:

Name	Company	ODH License Number	Expiration Date

**REGULATORY COMPLIANCE**

The Contractor certifies that all asbestos hazard abatement activities for this project will be performed in accordance with all applicable federal, state, and location asbestos regulations; including, but not limited to the United States EPA, Ohio EPA, OSHA, ODH, United States Department of Transportation, and Ohio Department of Transportation.

**OWNER COMPLIANCE**

The Contractor certifies that all asbestos hazard abatement activities for this project will be performed in accordance with all applicable OSU standards and guidelines; including, but not limited to the standards included within the OSU Building Design Standards, and OSU Environmental Health and Safety (EHS).

Within forty-five (45) business days of completion of the project, one (1) copy of closeout documents shall be submitted to the notified OSU EHS personnel; as noted above. At minimum, closeout documents must include the following: Asbestos Contractor License, Bureau of Worker’s Compensation (BWC) Certificate, Certificate of Liability Insurance, all ODH and EPA Notifications (including original and all revisions), Employee Submittals (ODH Card, EPA Training Certificate, Medical, Fit Testing), Material Safety and Data Sheets (MSDS), Personal and Environmental Air Sample Results, Clearance Testing Results, Daily Field Logs, Waste Manifests and Receipts.

**CONTRACTOR STATEMENT**

The Contractor attests that all of the above information is accurate and true to the best of their knowledge, and will perform all work at OSU with the highest ethical standard of care and practice within the industry in accordance with all applicable federal, state, local regulations, OSU EH&S standards, and any other applicable Contract Documents. No asbestos abatement work shall be performed prior to submission of the notification and the confirmed acceptance by OSU EH&S.

Name of Person Filing Notice: \_\_\_\_\_

Asbestos Abatement Company: \_\_\_\_\_

Date: \_\_\_\_\_

**ADDITIONAL WORKER CERTIFICATIONS / SUBMITTALS**

<b>Worker Name</b>	<b>ODH Card No./ Exp. Date</b>	<b>Training Cert. Exp. Date</b>	<b>Medical Exp. Date</b>	<b>Half Face Fit Test Exp. Date</b>	<b>PAPR Fit Test Exp. Date</b>

The Contractor certifies that all persons working on the project are currently licensed or certified by ODH.

**ADDITIONAL WORK AREAS**

Work Area: \_\_\_\_\_ (General Description)

Building Specific Location(s)	Type of ACM	Quantity of ACM (sf or lf)	Engineering Control(s) (Insert Applicable Numbers Below)

Notes (Use for Engineering Controls): (1) Full Negative Pressure Containment; (2) Negative-pressure Glovebag; (3) Wrap and Cut; (4) Negative Pressure Mini-Enclosure; (5) Regulated Area; (6) Three-stage Decontamination Chamber with Hot and Cold Water; (7) Critical Barriers; (8) Primary 6-mil Polyethylene Barriers; (9) Secondary 6-mil Polyethylene Barriers; (10) Polyethylene Drop Cloths; (11) Air-Filtration Devices Exhausted to Exterior of Building; (12) HEPA Vacuums (13) Wet Methods of Removal with Amended Water; (14) Encapsulation; (15) Other (Please specify)

Work Area: \_\_\_\_\_ (General Description)

Building Specific Location(s)	Type of ACM	Quantity of ACM (sf or lf)	Engineering Control(s)

Notes (Use for Engineering Controls): (1) Full Negative Pressure Containment; (2) Negative-pressure Glovebag; (3) Wrap and Cut; (4) Negative Pressure Mini-Enclosure; (5) Regulated Area; (6) Three-stage Decontamination Chamber with Hot and Cold Water; (7) Critical Barriers; (8) Primary 6-mil Polyethylene Barriers; (9) Secondary 6-mil Polyethylene Barriers; (10) Polyethylene Drop Cloths; (11) Air-Filtration Devices Exhausted to Exterior of Building; (12) HEPA Vacuums (13) Wet Methods of Removal with Amended Water; (14) Encapsulation; (15) Other (Please specify)

**SUBMIT--->**

## **Appendix F – Design Standards**



THE OHIO STATE UNIVERSITY

---

# **Building Design Standards**

## for Architects and Engineers

Prepared by

**The Ohio State University  
Facilities Operations and Development**

<b>BDS Table of Contents</b>	
<b>Design Process</b>	
Division 0	Design Process, Part 1
Division 00	Design Process, Part 2
<b>Contract Administration</b>	
Division 1	General Requirements
<b>General Trades</b>	
Division 2	Existing Conditions
Division 3	Concrete
Division 4	Masonry
Division 5	Metals
Division 6	Wood, Plastics, and Composites
Division 7	Thermal and Moisture Protection
Division 8	Openings
Division 9	Finishes
Division 10	Specialties
Division 11	Equipment
Division 12	Furnishings
Division 13	Special Construction
Division 14	Conveying Systems
<b>Plumbing, HVAC, Fire, Electric</b>	
Division 21-28 Facility Services	Facility Services - Document Requirements
Division 21	Fire Protection
Division 22	Plumbing
Division 23	HVAC
Division 26	Electrical
Division 27	Communications
Division 28	Electronic Safety and Security
<b>Site, Infrastructure, and Power Generation</b>	
Division 31	Earthwork
Division 32	Exterior Improvements
Division 33	Utilities
Division 40	Process Interconnections
Division 48	Electrical Power Generation (and Allied Facilities)
<b>Appendix</b>	
Appendix A	Building Automation System Specifications
Appendix B	Requirements for Access
Appendix C	Energy and Sustainability
Appendix D	Service Space Design Standards
Appendix E	Requirements for Survey Information
Appendix F	Standard Title Sheet and Title Block
Appendix G	Detail Drawings
Appendix G-1	Cleaning, Flushing, and Water Treatment Procedure

Appendix H	Sewer Auxiliary Metering Systems
Appendix I	Examples of Piling Cost Calculations
Appendix J	Ranges of Design Limits for Sound Controls
Appendix K	Technical Provisions for Corrosion
Appendix L	Sample Specs for Condenser Water Treatment
Appendix M	Communications Wiring Standard
Appendix N	Lab Hoods, Biosafety, and Laminar Flow Cabinets
Appendix O	Classroom Guidelines
Appendix P	Walkway Policy
Appendix Q	Tree Grading Standard
Appendix R	Window Air Conditioner Policy
Appendix S	Signage Standards
Appendix T	System Training Sample Specifications
Appendix U	High Pressure Steam Hot Water Converter and Steam Metering
Appendix V	Safety, Health, and Environment
Appendix W	Laboratory Hoods, Safety Cabinets, and Ventilation Systems
Appendix X	LEED Sustainability and Guidelines
Appendix Y	Basic Security Planning – Minimum Design Requirements
Appendix Z	Building Information Modeling
<b>Medical Center Appendix</b>	
Division 1 Medical Center	General Requirements
Division 8 Medical Center	Openings
Division 14 Medical Center	Conveying Systems
Division 21-28 Medical Center	Facility Services – Document Requirements
Division 21 Medical Center	Fire Protection
Division 22 Medical Center	Plumbing
Division 23 Medical Center	HVAC
Division 26 Medical Center	Electrical
Division 27 Medical Center	Communications
Division 28 Medical Center	Electronic Safety and Security
Appendix A Medical Center	Instrumentation and Control for HVAC
Appendix B Medical Center	Eyewash Guidelines
Appendix C Medical Center	Interiors
Appendix D Medical Center	Signage
Appendix E Medical Center	Electrical System Labeling and Identification



## **DIVISION 0 - THE DESIGN PROCESS**

2006 Edition, Published January 1, 2006; Revision Date: February 7, 2017

### **Part 1: Conceptual Design Guidelines**

#### **1.1 Introduction**

Campus buildings contribute to the accomplishment of the University's academic mission in two important ways: First, of course, they provide enclosed, comfortable, spaces that serve activities ranging from generating steam to teaching philosophy -- spaces that serve the practical, as well as the intellectual and emotional, needs of students, faculty, staff, and visitors. Second, the University's buildings create a campus that is the setting for a unique academic community--a campus that also must serve practical, intellectual, and emotional needs.

The Framework Plan (<http://pare.osu.edu/framework>), Design Guidelines for Buildings and Landscape (<http://fod.osu.edu/sites/default/files/buildings-landscape.pdf>) and their interpretation by Planning and Real Estate (PARE), offer direction for the development of the campus as a whole and the "Building Design Standards" guide architectural details and specifications. The conceptual design, which is focused in the schematic design process, falls between master planning and architectural detailing. Responsibility for schematic design direction rests with PARE, including the University Architect (UA) and University Landscape Architect (ULA) with input from professional designers from Architect/Engineer (A/E) firms and Facilities Operations and Development, together with members of the Project Planning Team.

The architectural program of requirements for each project reflects the point of view of both the user and the university as a whole. While the user's requirements will vary significantly from unit to unit, there are overall university-wide issues that must be considered in the design of all buildings and landscapes. A summary of these issues serves as a general guide for conceptual design at The Ohio State University.

There is remarkable agreement among lay persons and professional architects regarding the world's best campuses and the characteristics that contribute to this ranking. These characteristics, from which the conceptual guidelines were derived, fall generally into categories that (1) reinforce the sense of academic community; (2) support the process of learning; and (3) enhance the sense of heritage and tradition.

#### **1.2 Guidelines That Reinforce the Sense of Academic Community.**

In 1991, President E. Gordon Gee challenged The Ohio State University to "get back to the very nature of what a university must be: an intellectual community ... where each person is equally a teacher and a learner." As the physical setting for the University, the campus plays an essential role in creating this academic community. The principles presented in the - Framework Plan, together with the following guidelines, are directed toward the reinforcement of this sense of academic community.

- **Establish a harmonious balance of unity and diversity**  
The best campuses offer both a unity that reinforces the sense of academic community and a diversity that reflects an inexhaustible diversity of disciplines, activities, and cultures. On these campuses one has the sense that never in a lifetime of experiencing the place would you discover all that it has to offer.

## **Division 0 Part 1: Conceptual Design Guidelines**

---

- Design each component first as both an integral part of the campus and an individual entity. See Chapter 4, "Policies, Design Principles, and Review Procedures," in Volume II: Long Range Concept Plan of the Campus Master Plan.
  
- **Provide an integrated network of campus places and pathways**  
Campus places, rather than buildings, are the most memorable components of the University. These places cannot be created by simply accepting what is "left over" between buildings; they must be consciously developed as outdoor rooms. The role that buildings play in creating this network of campus places and their connecting pathways is addressed primarily in the - Framework Plan; however, this role must also be considered in the architectural design process; especially the early schematic design phase.
  - Locate and design facilities to complement and enhance the use of existing designated open, green spaces
  - Consider the design of each building and the design of its surrounding paths, landscape, views, etc. to be part of the same process
  - Recognize the major entrances and public spaces of campus buildings as part of the network of campus paths and places
  
- **Provide for change**  
The task of creating the campus is never finished; change is an on-going condition at a viable university. The campus and its buildings must embrace new demands and must be capable of meeting demands for minor renovations and additions as well major buildings and groups of buildings.
  - Design all buildings to be "complete" at all stages and, at the same time, to be capable of flexibly accommodating additions and renovations
  
- **Provide an accessible and safe campus that gives priority to the pedestrian**  
The academic community must provide convenient and safe access to all facilities for all persons. It should also provide an environment that minimizes pedestrian and vehicular conflicts and, at the same time, accommodates necessary functions of service, parking, etc. In addition to the following guidelines, the plans, principles, and policies of the - Framework Plan provide direction for accessibility and pedestrian priority.
  - Design parking garages, surface parking lots, and service areas that contribute to the overall unity of the campus and minimize the imposition of these functions
  - Incorporate integrated access and usability for individuals with disabilities into initial design considerations
  - Consider the possibility of informal monitoring of interior and exterior public

## **Division 0 Part 1: Conceptual Design Guidelines**

---

paths and gathering places in the layout of building spaces and corridors--  
Consider opportunities for combining parking structures, service areas, etc. with other functions to minimize the impact of these necessary utilitarian facilities

- **Establish campus boundaries that serve the overlapping interests and needs of the University and the surrounding communities**  
The academic community of the University extends beyond the borders of the campus. The University plays a critical role in establishing the quality of life in the surrounding neighborhoods. The best campuses have boundaries that recognize the overlapping social, aesthetic, and functional interests of the University and its urban neighbors.
- Recognize the paths, views, circulation patterns, and activities of the surrounding community to be among the design parameters for all facilities located on or near campus boundaries

### **1.3 Guidelines that Support the Process of Learning**

The best campuses stimulate self-questioning and discovery; serve as learning tools, provide places for meeting and exchange of ideas; and provide places for private study and meditation--they celebrate the process of learning. The following architectural guidelines direct the design of buildings that support the process of learning.

- **Design buildings and campus places that celebrate learning**  
Academic communities that, in President Gee's words "vibrate with a passion for learning," must celebrate the learning experience.
- Incorporate literal and symbolic aspects of University disciplines into the design of interior and exterior campus places.
- Design each learning space as a unique environment that confirms each assembly of persons as a special event that is not quite like any other on campus. While there may be occasions when special funds are available to enhance these unique environments, in most cases the challenge, of course, is to provide this environment with little or no additional cost. Designers are encouraged to consider provisions for incorporating permanent or rotating art and other exhibits as well as incorporating aspects of University disciplines (as suggested above) in the architectural ornament of the room: wood carved quotations or scenes on doors, friezes, wainscots, etc.
- **Design buildings and campus places to encourage informal learning**  
Learning is not limited to formal gathering in classrooms, auditoriums, and laboratories. Learning takes place anywhere and everywhere on the campus. Some of the most productive, often interdisciplinary, learning experiences are neither planned nor anticipated. The campus and its buildings must provide places that invite these informal scholarly exchanges which lead to the "collaborations and structure required for new knowledge."<sup>1</sup>

## **Division 0 Part 1: Conceptual Design Guidelines**

---

- Design building corridors and campus paths that encourage and support interdisciplinary, chance meetings and ad hoc discussions.- Design building corridors and related campus paths that permit, where appropriate, observation of, or participation in, on-going learning activities.
- Locate and design cafes, restaurants, vending areas, copy centers, etc. in conjunction with major circulation paths and, where appropriate, provide for both interior and exterior activities.
- Locate programmed galleries, museums, and exhibition spaces, as well as selected learning spaces in conjunction with major campus places and paths to permit "students, faculty, staff, and visitors to be engaged in the intellectual life of the University"<sup>2</sup> beyond the classroom.
- Design selected learning spaces (classrooms, studios, etc.) that support informally monitored gatherings of small groups for study and discussion when the space is not formally scheduled.
- **Design building and campus places that support individual study and meditation.**

The campus must offer places to be alone, to think, to meditate. No two persons are like; some wish to be alone in a crowd, others to be alone with their thoughts. The campus must permit each person to find her or his own place.
- Provide -- without compromising safety -- interior and exterior places that encourage and support individual study and meditation.

### **1.4 Guidelines That Enhance the Sense of Heritage and Tradition**

The best campuses remind residents and visitors of the academic lineage of the University. They commemorate the significant persons and events of the academic disciplines of the University and of the University itself. The following guidelines are directed toward the enhancement of a sense of historical continuity, of heritage and tradition, that is a basic ingredient of a community of scholarly inquiry. These guidelines overlap and reinforce the guidelines for supporting the learning process.

- **Reflect the heritage of the academic disciplines, as well as the persons and the events, central to the academic mission of the University.**
  - Incorporate, in the design of major public interior and exterior paths and places, features that commemorate contributions of academic disciplines, their founders, and their distinguished scholars.
  - Incorporate, in the design of major public interior and exterior paths and places, features that commemorate contributions of faculty, alumni, and staff of The Ohio State University.
- **Provide historic continuity**

As the University grows the campus and its buildings should present a rich

## **Division 0 Part 1: Conceptual Design Guidelines**

---

integration of new and old. Students, faculty, staff, and visitors should be reminded that they are part of a dynamic institution that is built upon the earlier contributions of many persons. This historical continuity is readily perceived when selected

buildings and landscapes from former periods are retained for continued service or when their location and appearance are preserved in their replacements.

- Design building renovations to preserve the essential architectural character and institutional history of historic buildings.
- Incorporate reminders of historic buildings and events within the design of new campus facilities--especially when historic buildings or the location of memorable events are involved.

<sup>1</sup> E. Gordon Gee, "From Vision to Action," A presentation to the University Senate, March 2, 1991, p. 2.

<sup>2</sup> Gee, "Vision," 1991, p. 8.

End of Section

## **DIVISION 00 – THE DESIGN PROCESS PART TWO**

2006 Edition, Published January 1, 2006; Division Revision Date: February 7, 2017

### **PART TWO - PROCESSING THE WORK**

#### **00010. UNIVERSITY INVOLVEMENT**

00011. UNIVERSITY PLANNING PROCESS: The University Capital Improvements process involves the participation of many University agencies. For help in understanding the earlier planning process and its role in the subsequent planning events, the Architect/Engineer (A/E) should contact the University Project Manager.

00012. ARCHITECT/ENGINEER'S RESPONSIBILITY TO THE UNIVERSITY ARCHITECT: Project planning is a cooperative procedure involving many persons within the University yet, during design and processing of documents, the A/E, as the agent of the University, will be required to work directly with the University Architect for authoritative answers on all design matters and those involving coordination with the University. The University Architect will review major design issues for its practicality, aesthetics, campus planning impacts and cost effectiveness. The Design Guidelines for Buildings and Landscape will guide design decisions.

00013. THE PROGRAM OF REQUIREMENTS is prepared in cooperation with the Using Agency concerned and with advice from other University agencies. The Program of Requirements is the single written source of information concerning the scope of the project and the detailed requirements to be achieved by the project. It is essential, at the very beginning of the design process that the A/E, seeks clarification from the University Architect regarding any question generated from its study of these Building Design Standards or the POR. All variations from these Building Design Standards shall be documented according to the process provided on the Building Design Standards web page, [fod.osu.edu/resources/](http://fod.osu.edu/resources/). When appropriate the University Architect will refer these questions to the Project Planning Team for resolution and response. Program changes will not be accepted solely upon request of the Using Agency's representatives.

.1 DESIGN WITHIN AVAILABLE FUNDS: A construction/renovation budget is developed for each project that establishes the maximum funds available for construction. The A/E shall continually monitor program requirements and cost estimates to assure that the project is designed within the available funds and does not deviate from the quality standards established in these Building Design Standards. Estimates of costs shall be projected to the proposed date for receipt of bids.

Should the A/E have doubts about satisfying at least priorities 1 and 2 of the POR, he must inform the University Architect without delay. Should the lowest bona fide bids for the construction of the project exceed the Fixed Limit of Construction Cost, the A/E will be required to assist in bringing the project back within the funds available. This may require modifying the drawings and specifications for the project without additional charges as per the contract for services with the University.

.2 ADD-ALTERNATES: The University prefers to avoid deduct-alternates unless circumstances justify their use and special permission is obtained from the University Architect. Carefully selected add-alternates are desirable to obtain the maximum number of priority 3 items and to fully utilize the available funds. Add-alternates must be items which can be added to the "base bid" design without causing major changes in the "base bid" design package.

.3 OHIO STATE BRAND GUIDELINES: The A/E and the University's planning team shall reference the Ohio State Brand Guidelines website ([brand.osu.edu/](http://brand.osu.edu/)) as it may apply to the project.

2006 Edition, Published January 1, 2006; Division Revision Date: February 7, 2017

## DIVISION 0 PART 2: PROCESSING THE WORK

---

00014. THE PROJECT SITE: The selected site for the project is described in the POR . The University \_Framework Plan, Landscape Master Plan, and District Plans, which have been adopted by the Board of Trustees, include design and development guidelines that provide a diagrammatic framework for land use, circulation, parking, landscape design, and building placement. Information about those plans is available on the OSU Master Planning website (<https://pare.osu.edu>). For most sites, there are area-specific guidelines that are applicable to defined sectors of the campus and provide the A/E with guidance concerning the development of the project site. The A/E shall visit the site prior to the Initial Planning Conference in order to understand the limitations and opportunities at the site and to formulate any questions about site conditions and the application of design and development guidelines. The A/E is free to suggest modifications as long as suggested rearrangements clearly adhere to plan principles and guidelines. The A/E is encouraged to retain a professional landscape architect and/or a physical planner for the purpose of dealing with site issues. The use of the services of a professional landscape architect will be required when the university determines that those services are needed to fulfill project requirements.

### 00015. CONFERENCES:

- .1 INITIAL PLANNING CONFERENCE: Immediately after the A/E has been confirmed by the University, the University Project Manager will schedule a meeting for the purpose of discussing the University Conceptual Guidelines and general requirements of the program and procedures for expediting the A/E's work. The University will be represented by the Official Planning Committee. It is MANDATORY that the A/E's professional consultants, (including his fire protection, plumbing, HVAC, and electrical consultants) attend this conference.
- .2 ADDITIONAL CONFERENCES: Additional conferences will be held to (1) discuss and clarify ways in which the University's Conceptual Guidelines relate to the project, (2) to clarify the Program of Requirements, (3) to review and discuss the A/E's evaluation of achievability of priority 1 and 2 requirements within budget constraints and to assist in definition of alternates, which will become an important component of the construction documents. Participants in these conferences are named in the Program of Requirements. All conferences will be scheduled by the University Project Manager.
- .3 BASIC SECURITY PLANNING CONFERENCE: The A/E and the Project Manager shall consult with the Department of Public Safety to determine the specific security requirements for the project. Refer the BDS Appendix Y. Included the agreed upon security requirements in the POR.
- .4 CONFERENCE MEMORANDA: The A/E is responsible for the proper recording of the business content of all conferences. Within seven days following any conference, copies of a memorandum, containing a complete summation of decisions and actions and affecting the project, shall be delivered to the University Project Manager for distribution to all OSU conferees. Copy quantity for The University will be determined by adding three copies to the number of OSU participants in the meeting. The A/E will deliver memoranda copies to all conferees other than OSU participants.
- .5 FORMAT FOR MEMORANDA: Memoranda shall be numbered in consecutive order. Summations shall be in outline form with numbered paragraphs and alphabetical sub-paragraphs. Although statements should be brief, each statement shall convey the entire message and shall clearly state the problem or directed decision. All pertinent information shall be provided in the statement: one word statements, and terse phrases and clauses should be avoided.

## DIVISION 0 PART 2: PROCESSING THE WORK

---

00016. DESIGN STAGES: During the planning period the A/E is required to make submittals of three stages of the project development which coincide with the contractual agreement for fee payment.

The three stages are:

.1 SCHEMATIC DESIGN DOCUMENT STAGE.

GENERAL NOTE: During the early stages of the Schematic Design development, the A/E is required to consult with the University Architect and University Engineer to review conceptual solutions. The material can be in "sketch form" showing possible design solutions that can be expanded upon during the development of the final schematic submittal. More than one study will be required for review. The purpose of these "mini design sessions" is to assist the A/E in the development of an acceptable final schematic design submittal. If this procedure is not followed, there are strong possibilities that the formal schematic design submittal will be disapproved by the University.

.2 DESIGN DEVELOPMENT DOCUMENT STAGE.

.3 CONSTRUCTION DOCUMENT STAGE.

00017. SCHEMATIC DESIGN DOCUMENT STAGE:

.1 SUBMITTAL shall consist of:

.1.1 A site plan, showing adjacent buildings, existing and proposed contours, and existing sewers and other utilities. Refer to Paragraph 00014 for requirements relative to siting of the project. If a project involves any site improvements, the site plan shall be based on a surveyed base map.

.1.2 All floor plans - For each room or space, identify with Program of Requirements Room Name and Program of Requirements Item Number. Also see 00041.8.

.1.3 All elevations.

.1.4 A section through the entire building selected to best show the relationships of architectural and engineering features.

.1.5 Equipment and furniture layouts for all floors.

.1.6 A Database file which compares the Assignable Square Footage (ASF) of the Program of Requirements to that of the Schematic Design Document. This submittal must be in the following format:

Title Block  
Project Name:  
Project Number:  
Project total gross square feet (GSF):

Column	Column Header
1	PoR Item Number
2	PoR Room Name
3	PoR Priority
4	PoR Number of Rooms



## DIVISION 0 PART 2: PROCESSING THE WORK

---

5	PoR ASF
6	Schematic Design Number of Rooms
7	Schematic Design ASF
8	PoR/Schematic Design ASF Difference
9	Comments

This file should also contain a subtotal by Program Item Number Group (e.g. all spaces under Program Item Number 1.0 would be subtotaled.) A project total ASF should also be included (totals all Program Item # Group ASFs).

- .1.7 Tabulation of floor areas, cubic contents, and a construction cost estimate shall be provided in both hardcopy and electronic format (Microsoft Excel). Show estimated cost per square foot and per cubic foot. Indicate new construction costs, remodeling costs, including major and minor areas of remodeling, with approximate areas. Coordinate with Program of Requirements item numbers. Tabulations may be combined. Also see 00013.
  - .1.8 An outline specification, indicating materials, and types of construction. Include a description of each plumbing, HVAC, fire protection, and electrical system design concepts, a one-line diagram of the electrical service (if applicable) and a narrative description of the design criterion for the noise and vibration control for these systems.
  - .1.9 Schematic models usually are not required, but study models might be considered for submittal at this stage, if unusual conditions suggest that study models might aid in the review of the drawings.
  - .1.10 A letter describing conceptual design element life cycle analysis shall be submitted.
  - .1.11 OSU Green Build and Energy Policy #3.10 ([http://fod.osu.edu/proj\\_del/index.htm](http://fod.osu.edu/proj_del/index.htm)): Provide a narrative description of the proposed building envelope and HVAC/Electrical/Plumbing system modification options to show compliance with Policy #3.10, including HVAC schematic one-line flow diagrams for the air systems, hydronic systems, and steam systems.
00018. DOCUMENTS REVIEW: A conference will be held to review documents at this stage. Prior to printing the documents for distribution, the A/E shall review one complete set of documents with the University Project Manager to verify that submittal contains sufficient information for review process. When documents are deemed acceptable, the University Project Manager will provide the A/E with a listing of quantity of documents required to be provided by the A/E for distribution. List will consist of full sets for certain participants and partial sets or individual sheets for others with specialized interest in the project.
- At least seven workdays will be required for review by the recipients prior to the scheduled meeting. See 00015 regarding memoranda. More review time may be required for larger and/or more complex projects.
- After the documents have been received and distributed, the University Project Manager will schedule the review conferences and obtain approval signatures of the persons named in the Program of Requirements.
00019. APPROVAL SIGNATURES: Signatures of University officials following the words "Approved by" or "Examined by" do not express approval of technical sufficiency nor accuracy of the information shown, but do signify that the Project as shown and described by the documents

## DIVISION 0 PART 2: PROCESSING THE WORK

---

generally conforms to the Program of Requirements, adequately responds to the Conceptual Design Guideline and that the estimated cost of the project is within available funds.

00020. ADDITIONAL PRINTS: After schematic drawings have been approved, two prints of each floor plan shall be furnished to the University Project Manager for submittal to Facility Planning for assignment of room numbers. The University Project Manager will return one print, with required room numbering, to the A/E for use in transferring room numbers to the project drawings. Refer to Paragraph 00041.8.

00021. DESIGN DEVELOPMENT DOCUMENT STAGE:

DRAWINGS AND Project Manual shall be prepared in conformance with Section 153.50 and 153.52 of the Ohio Revised Code. The A/E shall work with the University Project Manager (PM) to identify the appropriate submittal content and timing for the formal University wide review. Refer to the Review Process Summary at: <http://fod.osu.edu/project-delivery> The Ohio State University requires separate documents to be prepared for each of the following: General; Plumbing; HVAC (Heating, Ventilating, and Air Conditioning); Fire Protection; and Electrical.

Drawings for this submittal should be progress prints made from partially finished construction document drawings. The Project Manual shall include a draft of Divisions 00 and 01 and the outline specifications shall be updated in accordance with comments received at the conference for review of schematics. It is recommended to start the Construction Document submittal at this time. A quantity take off detailed estimate of cost shall be included in this submittal and it shall be provided in both hardcopy and electronic format (Microsoft Excel). Square foot and lump sum estimates are not acceptable.

.1 SUBMITTAL shall consist of:

.1.1 Site plans showing adjacent buildings, proposed site improvements, existing and proposed contours, existing and proposed sewers and other utilities. Provide separate site plans for General Construction; Plumbing; Heating, Ventilating, and Air Conditioning; and Electrical Work.

.1.1.1 When a site survey has been made by a professional surveyor, a facsimile of the surveyor's drawing must be included with the site plan prepared by the A/E. This survey plan sheet size should be the same as other sheets in the set; if surveyor's drawing is too large, a reduction in scale will be required.

.1.1.2 Profiles of proposed utilities and cross sections of the proposed site grades shall be included if applicable.

.1.1.3 Hydraulic: A stormwater management calculation package shall be submitted with appropriate sketches and drawings. It shall also include the following items:

- Signed and sealed stormwater calculations
- Drainage area map with onsite and offsite areas delineated
- Soils map
- Curve number determination, any calculation of composite curve numbers, and appropriate sketches for all proposed storm and/or sanitary sewers.

.1.1.4 Geotechnical Report and Pavement Design Calculations.

- Any applicable permits, including but not limited to, City of Columbus, ODOT, ODNR, FEMA, and US Army Corp of Engineers

## DIVISION 0 PART 2: PROCESSING THE WORK

---

- .1.2 Site landscaping development plan, prepared by a Landscape Architect when project includes substantial site work.
- .1.3 All floor plans, showing vertical pipe and duct spaces, structural columns, and principal architectural and engineering features. If sheet size is sufficient, each sheet shall contain a schedule of floor, ceiling, and wall finishes for the floor shown on that sheet. Include Program of Requirements Item Numbers, Room Names and Assigned Room Numbers. Also see 00041.8.
- .1.4 A roof plan showing all slopes; key reference roofing high point, valley and drain elevations (altitudes referenced to project benchmark); roof drains; penetrations; walkways; large piping; air ducts; fans; condensers; roof structures; equipment screens and ladders.
- .1.5 Elevation drawings of every exterior side of each structure showing materials, features, openings, floor and roof lines, grade lines, footings and everything exposed to view above eaves or parapets. Visual screening of roof mounted clutter or equipment is required.
- .1.6 Longitudinal and cross sections through the building, selected to best show the relationships or architectural and engineering features.
- .1.7 Equipment and furniture layouts for all floors.
- .1.8 Live loads for floors must be shown on plans.
- .1.9 Fire Protection: Provide current hydrant flow test data and, if applicable, the fire pump sizing and selection data and equipment room layout.
- .1.10 Plumbing system floor plans showing equipment, fixtures, Drain Waste Vent piping, domestic water piping and gas piping (if applicable). Provide design calculations for sanitary, natural gas loads and domestic cold/hot water systems.
- .1.11 HVAC system major design calculations.
  - .1.11.1 HVAC system equipment room locations; showing equipment major piping and ductwork sized for all floors in the building shall be submitted.
  - .1.11.2 Provide THERMAL STRESS ANALYSIS for the steam and condensate piping systems, as well as campus chilled water piping distribution in accordance with ASME B31.1 Power Piping Design and Fabrication and the OBC Pressure Piping Systems Code. Provide piping isometric diagrams with pipe lengths and node location identifiers shown for cross reference with the calculations. Note all assumed design criteria and pipe material selection, diameter and schedule. Results shall show the different modes of operation: pressure, pressure and temperature, pressure, temperature and weight. Also provide results for cold and hot pipe configurations if needed.
  - .1.11.3 HVAC heat loss and heat gain calculations for building and/or HVAC system loads: Provide a summary of zone loads, central air handling system loads and hydronic system loads showing a breakdown of internal, envelope and ventilation loads. Note all assumed design criteria.
  - .1.11.4 HVAC outside air ventilation and minimum supply air quantity calculations for each air handling system to show compliance with ASHRAE Standard 62.1-2013 (or current edition).

- .1.12 A Database file which compares the assignable square footage (ASF) of the Program of Requirements to that of the Schematic Design Document and the Design Development Document. This submittal must be in the following format:

Title Block	
Project Name:	
Project Number:	
Project total gross square footage (GSF):	
Column	Column Header
1	PoR Item Number
2	PoR Room Name
3	PoR Priority
4	PoR Number of Rooms
5	PoR ASF
6	Schematic Design Number of Rooms
7	Schematic Design ASF
8	PoR/Schematic Design ASF Difference
9	Comments
10	Design Development Number of Rooms
11	Design Development Room Number(s)
12	Design Development ASF
13	PoR/Design Development ASF Difference
14	Comments

This file should also contain a subtotal by Program Item Number Group (e.g. all spaces under Program Item Number 1.0 would be subtotaled). A Project total ASF should also be included (totals from all Program Item # Group ASFs).

- .1.13 OSU Green Build and Energy Policy #3.10 and Life-Cycle Cost Analysis: Provide updated narrative descriptions of proposed building envelope and HVAC/Electrical/Plumbing system options to show compliance with Policy #3.10, including HVAC schematic one-line flow diagrams for the air systems, hydronic systems and steam systems. The backup documentation and calculation requirements for these building system options are outlined in the BDS Appendix C – 1.2. Policy 3.10 Energy Compliance Documentation Submittal Requirements.” The life-cycle cost analysis shall be prepared pursuant to Sections 153.01, 153.04, and 153.10 of the Revised Code of the State of Ohio and in accordance with rules adopted under Chapters 3781 and 4101
- .1.14 Electrical submittal shall include:
- .1.14.1 Electrical system showing fixtures and equipment.
  - .1.14.2 Riser diagram indicating connections and wiring to main switch, distribution, power and lighting panels.
  - .1.14.3 Panel and switch schedule.
  - .1.14.4 Information regarding clearances between high voltages and low voltage circuits and distances from transformers, other equipment and buildings.
  - .1.14.5 Electrical system major design calculations and analysis of loads including short circuit calculations, photometric calculations, voltage drop calculations for service entrance, service drop and secondary conductors, demand factors

## DIVISION 0 PART 2: PROCESSING THE WORK

---

used, calculations determining load availability of existing transformer and capacity to accommodate additional load.

.1.14.6 Fire alarm system riser diagram and function matrix.

.1.14.7 Lighting fixture quantities, including foot candle levels, shall be included. Submit lighting fixture catalog cuts and lamp catalog cuts including lamp life and unit costs per lamp.

*NOTE: The University reserves the right to prohibit use of any fixtures, based on lamp life or lamp cost.*

.1.15 Structural engineering calculations to analyze and check the load carrying capacities of various structural members.

### 00022. CONSTRUCTION DOCUMENT STAGE:

- .1 SUBMITTAL: The expectation for the Construction Document (CD) phase submittal is for the University to receive Drawings and a Project Manual that are 100% complete and ready to be issued for bidding.
- .2 During the review interval, any changes required by Facilities Operations and Development, the Industrial Compliance Division, or other State Agencies, must be made, preferably not by Addenda.
- .3 CODE INFORMATION: On the title sheet of the drawings and on the title page of the Project Manuals, show the Ohio Building Code (OBC) "updated through" date that was used for design, use group classification, type of construction classification and the area of each floor.
- .4 A Database file which compares the assignable square footage (ASF) of the program of requirements to that of the Schematic Design Document, the Design Development Document, and the Construction Document. This submittal must be in the following form at:

Title Block

Project Name:

Project Number:

Project total gross square footage (GSF):

Column	Column Header
--------	---------------

1	PoR Item Number
---	-----------------

2	PoR Room Name
---	---------------

3	PoR Priority
---	--------------

4	PoR Number of Rooms
---	---------------------

5	PoR ASF
---	---------

6	Schematic Design Number of Rooms
---	----------------------------------

7	Schematic Design ASF
---	----------------------

8	PoR/Schematic Design ASF Difference
---	-------------------------------------

9	Comments
---	----------

10	Design Development Number of Rooms
----	------------------------------------

11	Design Development Room Number(s)
----	-----------------------------------

12	Design Development ASF
----	------------------------

13	PoR/Design Development ASF Difference
----	---------------------------------------

14	Comments
----	----------

15	Construction Document Number of Rooms
----	---------------------------------------

16	Construction Document Room Number(s)
----	--------------------------------------

17	Construction Document ASF
----	---------------------------

18	PoR/Construction Document ASF Difference
----	--

19	Comments
----	----------

## DIVISION 0 PART 2: PROCESSING THE WORK

---

This file should also contain a subtotal by Program Item Number Group (e.g. all spaces under Program Item Number 1.0 would be subtotaled). A Project total ASF should also be included (totals from all Program Item # Group ASFs).

### .5 ADDITIONAL SUBMITTALS:

- .5.1 RENDERINGS, as required by the A/E's contract.
- .5.2 A MODEL shall be submitted at this stage, if required by the A/E's contract.
- .5.3 TWO COPIES OF CIVIL, STRUCTURAL, HVAC, PLUMBING, FIRE PROTECTION AND ELECTRICAL DESIGN CALCULATIONS shall be furnished to assist University personnel in review of the documents. As a minimum, this should include the final updated calculations of all calculations required in the Design Development submittal, including the finalized THERMAL STRESS ANALYSIS modeling.
- .5.4 An updated detailed quantity estimate of cost showing final square foot and all material quantities shall be submitted in both hardcopy and electronic format (Microsoft Excel). All labor and material should be broken out separately
- .5.5 OSU \_ Green Build and Energy Policy #3.10 and Life-Cycle Cost Analysis: Provide updated and final narrative descriptions of the Building envelope and HVAC/Electrical/Plumbing systems to show compliance with Policy #3.10, including final HVAC schematic one-line flow diagrams for the air systems, hydronic systems and steam systems. Provide backup calculations for these building envelope and system configurations.

### 00023. DOCUMENT REVIEW: See 00018.

- .1 Review of construction document submittal will require approximately ten work days or more, depending upon the complexity of the project and quantity of documents.

After approval is received from planning participants, the University \_ Project Manager will obtain necessary signatures on the drawing cover sheet\_ \_.

Signed cover sheets will be returned to the A/E to secure the approval and seals of the Industrial Compliance Division and State Board of Health.

- .2 REVIEW COMMENTS: At the time of, or prior to, issuance of the last Addendum during the bidding period, the A/E shall advise the University Architect in writing that all comments, changes, etc., resulting from document review by the Industrial Compliance Division, \_ Fire Marshal, University, and other agencies having review authority, have been incorporated into the construction contract documents. In the case of the exceptions, the A/E must indicate date, meeting, item, etc. involved in the resolution. Following receipt and approval of the responses to the review comments, the A/E shall submit three copies of the revised documents for review by Facilities Design and Construction.

### 00030. DESIGN

- 00031. UNIVERSITY ARCHITECT'S INVOLVEMENT IN THE DESIGN PROCESS: The A/E is required to involve the University Architect in the entire design process. The University Architect is as interested in the response to the Conceptual Design Guidelines as the solution of the specific problem needs stated in the Program of Requirement. It is especially important that the A/E understand the high priority that the University places upon the role of each

## DIVISION 0 PART 2: PROCESSING THE WORK

---

facility in the creation of the overall campus. No building will be permitted to be designed in isolation. All buildings contribute to the achievement of overall University goals and, as a result, they will be different from buildings designed for other sectors of our society.

The A/E is expected to confer with the University Architect often, especially during the early conceptual design phase. Submission of a detailed, final, schematic design without prior review may result in rejection of the entire preliminary submittal and require complete redesign. The University Architect shall be the final design jurist.

00032. **QUALITY DESIGN:** Unless otherwise stated in the POR, buildings shall be designed as quality institutional buildings and heavy duty components shall be selected and specified to provide maximum life cycle usefulness. The requirement that the project be designed within available funds is not a license to design short life-cycle, speculative-type construction or to specify inferior or inappropriate materials.
00033. **USE OF PROFESSIONAL CONSULTANTS:** On all architectural and engineering projects for which enclosed structures are designed, the services of licensed professional architects and engineers are always required for the Architectural, Structural, Civil, Plumbing, HVAC, Fire Protection, and Electrical design. Sprinkler consultant must be capable of hydraulic design. On major projects, the services of other licensed professional specialists (Landscape, Acoustic, Food Service, etc.) might be required, as determined by the complexity of the project. The A/E shall closely supervise work done by his professionals, whether "in-house" or independent, to assure coordination of all parts of the total project. The University Architect reserves the right to direct the work of professionals through the A/E.
- .1 **TOPOGRAPHIC SURVEYS AND SOILS ANALYSIS REPORTS:** Is the responsibility of the A/E to accomplish. Costs of these services will be paid from the Project funds on an actual cost basis without fee mark-up. Any available record drawings from previous projects or the Utility Atlas maintained by Facilities Operations and Development will be made available. The University cannot warrant that information shown on record drawings is correct; therefore, the A/E must supplement this information with field surveys and measurements. The A/E is responsible for the accuracy of information shown on the contract drawings. See Appendix E for survey requirements.
00034. **DESIGN FOR CONSERVATION OF ENERGY- OSU \_ Green Build and Energy Policy 3.10:** The University is dedicated to the principle of conserving energy. University personnel will scrutinize proposed construction for means of reducing not only initial cost of energy consuming equipment, but also long-range operating costs. The A/E must work in harmony with its consultants to design new buildings and to remodel existing buildings to make the most efficient use of building materials and energy sources available. Also see BDS Divisions 21 – 28 Facility Services \_- Document Requirements and Appendices for the requirements related to Policy #3.10.
- .1 **DESIGN OF HVAC AND ELECTRICAL SYSTEMS:** Consideration must be given to building utilization by planning for conservation of energy during summer and winter vacations and for other periods of minimum occupancy. Research laboratories, spaces for animals, and other spaces which might require operation 24 hours a day must be serviced by systems separate from systems for offices, which might require operation for only 8 hours a day, and classrooms, which may be shut down during summer and vacation periods.
- .1.1 **PROVISIONS FOR ALTERNATE SOURCES OF ENERGY:** Of extreme importance is the capability of using alternate sources of energy. If gas-fired boilers are installed, the facilities must be provided with standby equipment for use of other fuels or sources of energy.

## DIVISION 0 PART 2: PROCESSING THE WORK

---

- .1.2 LIGHTING SYSTEMS are considered a source of heat to supplement heating requirements and recovery systems shall be provided wherever practicable.
  - .1.3 WINDOW BLINDS AND SHADES are considered to have a significant affect to HVAC and lighting conditions in a building. Automatic window blind and shade controls shall be provided wherever practicable to support and enhance energy efficiency for building systems.
  - .2 LIFE-CYCLE COST ANALYSIS: The A/E shall submit to the University a life-cycle cost analysis, which has been prepared in cooperation with his Architectural, HVAC and Electrical consultants. The analysis shall be prepared pursuant to Sections 123.001, 153.01, 153.04, and 153.10 of the Ohio Revised Code and in accordance with rules adopted under Chapters 3781 and 4101. The Life Cycle Cost Analysis shall be included with the submittal addressing the OSU Green Build and Energy Policy #3.10.
00035. NOISE AND VIBRATION CONTROL: Noise and vibration in terms of emission control and transmission control is the combined responsibility of the A/E and its consultants and must be considered in the design of every building, or space, even though specific requirements might not be stated in the POR. Three principle considerations which must be given to noise and vibration control are:
- .1 NOISE CONTROL TO PROVIDE FOR MAXIMUM USEFULNESS OF THE FACILITY by keeping levels of sound within ranges which are conducive to study and work or other uses for which the facility is designed.
  - .2 NOISE CONTROL IN COMPLIANCE WITH OSHA REQUIREMENTS for the health and safety of building occupants; control shall be for all areas of the facility, including equipment rooms, boiler rooms, PRV stations, and fan rooms. Set a maximum acceptance level of 85 dBA for new equipment.
  - .3 VIBRATION CONTROL to limit sound produced by equipment and for protection of the equipment and the building structure.
  - .4 RANGES OF SOUND CONTROL LIMITS required for indoor design are shown in the Appendix. These standards must be followed.
    - .4.1 CONTROL OF BUILDING EQUIPMENT (HVAC, ELECTRICAL, ETC.): Special attention shall be given to proximity by keeping noise producing equipment removed as far as possible from areas requiring low sound levels. Refer to Division 22, 23, and 26 for specific means of reducing noises from these sources.
  - .5 TESTS: A post-construction sound test shall be specified to prove the integrity of sound control where control is critical, and on a random sampling basis in other areas if deemed necessary. Specifications shall require that noise tests to be performed with a Type 1 precision sound level meter complying with ANSI - Standard S1.4-1983.
00036. PLANNING FOR SERVICE AREAS: Required, but not necessarily identified in the program. All service rooms or areas (i.e., custodial closets, trash rooms, maintenance control rooms, equipment rooms, mail rooms, etc.) shall be adequately ventilated, by natural or mechanical means (especially if human occupancy is required), The A/E shall work with appropriate stakeholders to ensure that the following areas are properly incorporated into the design:
- .1 CUSTODIAL SPACES: For new buildings on the Columbus Campus, provide the following custodial spaces; for regional campuses, consult the Director of Building Services at the campus involved; requirements might differ from those specified herein.



## DIVISION 0 PART 2: PROCESSING THE WORK

---

- .1.1 CUSTODIAL EQUIPMENT STORAGE ROOM: shall be strategically located on all floors throughout the building for the storage of custodial cleaning equipment. Minimum size of 55 square feet is required. Provide one room per 22,000 gross square feet. One room can serve two floors, if 22,000 square feet is the limit and an elevator is convenient to the closet. Locate to avoid moving equipment long distances. Typical equipment and sizes are, but not limited to:
  - .1.1.1 Mopping cart - 2 feet by 6 feet
  - .1.1.2 Trash cart (6 bushel) - 2 feet by 3 feet
  - .1.1.3 Vacuum, carpet (upright) - 2 feet by 1 foot
  - .1.1.4 Floor machine (buffer) - 2 feet x 4 feet +
  
- .1.2 CUSTODIAL WET CLOSET: Provide one strategically located room per 22,000 gross square feet and at least one room per floor. These closets may be combined with custodial equipment storage rooms. Each closet shall be equipped with a floor sink, shelving, and mop holders. Each closet to be Minimum size 60 square feet and shall contain the follow, but not limited to:
  - .1.2.1 32-inch x 32-inch or 30-inch x 24-inch floor basin with approximately 4-inch curb height.
  - .1.2.2 Hot and cold water outlet with attached hose (and wall clip) for filling buckets, etc.
  - .1.2.3 Three or more dry mop and dust mop hooks or clips on wall away from basin.
  - .1.2.4 Three or more wet mop hooks or clips arranged to permit dripping of wet mops into basin.
  - .1.2.5 Pad/brush holder.
  - .1.2.6 Step ladder - 1 foot x 2 feet
  - .1.2.7 Vacuum, wet or dry - 2 feet x 3 feet
  - .1.2.8 Shelving - 1 foot deep x at least 15 lineal feet of adjustable shelving.
  - .1.2.9 Electric receptacle, grounding type located approximately 2 feet above the floor and near the corridor door.
  
- .1.3 CUSTODIAL RECEIVING AND STORAGE ROOM near a loading dock, or near an elevator on the lowest floor for bulk storage of custodial supplies, may require limited shelving. The room shall be at least 80 square feet to serve a building size up to 45,000 gross square feet, 100 square feet to serve a building over 45,000 square feet up to 130,000 gross square feet, and 140 square feet to serve a building having over 130,000 gross square feet.
  
- .1.4 DRY TRASH ROOM shall open directly onto a loading dock, and to an inside corridor. Hot water, cold water, and floor drains shall be provided in each trash room which serves a kitchen facility. Trash rooms shall be of fireproof construction, and shall be protected with sprinklers. The room shall have a minimum size of 100 square feet to serve a building size up to 45,000 gross square feet, 120 square feet to serve a building over 45,000 square feet up to 130,000 gross square feet, and 160 square feet to serve a building having over 130,000 gross square feet.
  
- .1.5 WET WASTE OR HAZARDOUS WASTE ROOM of 60 square feet minimum must be provided for chemistry or similar laboratory facilities. If required by the building

## DIVISION 0 PART 2: PROCESSING THE WORK

---

usage, the room shall be located directly off the loading dock and from a corridor. The room shall be fireproof and provide other protection as determined by the nature of the waste material.

- .1.6 ADDITIONAL REQUIREMENTS for custodial spaces are as follows:
  - .1.6.1 Doors shall swing out and shall be large enough to permit free movement of boxes and equipment.
  - .1.6.2 Custodial Wet Closets shall have exposed concrete or painted drywall ceiling, hardened smooth concrete floor, and washable hard smooth finish on concrete block walls. Provide glazed tile walls at basin.
  - .1.6.3 Finishes in other custodial spaces shall be similar to those for Custodial Wet Closets.
  - .1.6.4 Provide positive ventilation.
  - .1.6.5 Lighting shall be 75 footcandles, flush in ceiling.
  - .1.6.6 No rooms shall contain telephone switchgear, elevator panels, electric panels, metering devices or similar equipment.
- .1.7 FACILITIES MAINTENANCE CONTROL ROOM: The location of the control room shall be determined with input from all appropriate stakeholders. The minimum size of the room shall be 80 square feet to serve a building size up to 80,000 gross square feet, 100 square feet to serve a building over 80,000 square feet up to 175,000 gross square feet, and 160 square feet to serve a building having over 175,000 gross square feet..
  - .1.7.1 CONTENTS of the room shall include at least the following:
    - .1.7.1.1 Plan rack to hold a full set of record drawings.
    - .1.7.1.2 Chair and desk or table.
    - .1.7.1.3 Telephone.
  - .1.7.2 EQUIPMENT such as telephone switchgear, elevator panels, electrical panels, metering devices or similar equipment, shall not be located in this room.
- .2 MAIL ROOM: The A/E shall provide a primary Mail Room for US Mail and University Mail delivery and distribution adjacent to the building entrance or loading dock for each new building or building renovation. Room size shall be applicable to the number of departments serviced in the building and volume of delivery. Minimum room size shall be 100 square feet. Secondary Mail Rooms on upper floors may be required for applicable mail distribution.
- .3 EQUIPMENT ROOMS: Transformers, boilers, pumps, tanks, heat exchangers, and other large equipment shall be located to permit easy servicing, operation and removal. Provide adequate circulation areas around equipment, including valves and accessory piping. Plans and elevations, at a scale of not less than  $\frac{1}{4}'' = 1' - 0''$ , shall be prepared for each room, to show that adequate circulation areas are provided.
  - .3.1 TELEPHONE AND DATA COMMUNICATIONS EQUIPMENT ROOMS

- .3.1.1 MAIN DISTRIBUTION FRAME (MDF): Provide a dedicated room, having 100 square feet minimum. No other services shall be included in this room. Provide appropriate electric receptacles, lighting and empty conduits. Locate near the point where main communication services enter the building and access directly from a corridor with an outswing door. This room is to accommodate fiber optic cables, CATV, and telephone services connections. Refer to APPENDIX M: THE OHIO STATE UNIVERSITY COMMUNICATIONS WIRING STANDARD for details.
- .3.1.2 INTERMEDIATE DISTRIBUTION FRAME (IDF) : Provide a dedicated room having 64 square feet minimum to house distribution equipment for that floor. Provide conduit risers to the MDF, electric receptacles and lighting. Access directly from a corridor with an outswing door. No other service shall be included in this room. Refer to APPENDIX M: THE OHIO STATE UNIVERSITY COMMUNICATIONS WIRING STANDARD for details.
- .3.2 PROTECTION FROM FLOODING:
  - .3.2.1 Electrical switchgear, panels, substations, chillers, pumps, tanks compressors, and similar items of equipment shall be placed on raised concrete pads. Pads shall be a minimum of 4 inches high to aid housekeeping and protect equipment.
- .3.3 ACCESS TO EXISTING, NEW, OR TEMPORARY UTILITY CONTROL DEVICES, valves, switches, manholes, etc. shall be maintained throughout the course of construction.
- .4 LOADING DOCKS: Provide a loading dock at each new building or major renovation. Provide the loading dock with three slots, one for deliveries, one for recyclable dumpster, and one for non-recyclable dumpster. A three-slot loading dock is especially important for buildings designed for extensive turnover of Users, extensive 'churn' of (relatively) short-term research projects, etc. Doors shall be at least 9'-0" (?) wide and should be 12'-8" (?) minimum on center when multiple doors are used. Pavement slope is a serious concern relative to drainage and to truck bed floor/building floor/canopy relationship. Loading docks shall be at the same elevation as a floor of the building and shall be either 44 inches minimum to 46 inches maximum above the adjacent pavement or shall be provided with a load leveler. Verify height requirements with the University Project Manager ; a different dock height might be required if stepvan vehicles, only, are used. Loading docks must not be located at or near fresh air intakes for buildings. Unless this is done, the exhaust from idling vehicles will be drawn into buildings and expose inhabitants to toxic airborne contaminants.
- .5 TRASH DUMPSTER: The University desires to screen trash dumpsters and provide a safe efficient work place for its employees. Design for the following conditions unless this requirement is waived by the University Architect: Provide interior space for two dumpsters (one for recyclables, and one for non-recyclables) at grade in front of the loading dock with 12-foot(?) roll-up doors to allow a 'packer' truck to retrieve, empty and replace the dumpsters within the space. Provide a concrete pad 12" thick of sufficient length to accommodate a 36' long packer truck making the retrieval and replacement of the dumpsters. Provide 3-phase power to the dumpster area to accommodate future need for either a trash compactor or vertical bailers. In addition to screening, the intent of this requirement is to allow recyclables and trash to be deposited in the dumpsters from the loading truck in a sheltered environment. Typical 8-yard dumpster sizes are: 82" (Length) x80" (Width) x76" (height). Separation

## DIVISION 0 PART 2: PROCESSING THE WORK

---

- clearance between the dumpsters and the screen is 30". Typical 20-yard roll-off box is 96" wide.
- .5.1 Construction sites: Include sufficient space and annotate on the site drawings for contractors to provide dedicated dumpsters, minimum one for recyclables and one for non-recyclables.
  - .6 PIPE SPACES: Pipe spaces shall be of width required for servicing of piping, but minimum clear width shall be 2-feet 0-inches. Provide access doors with lockset. When in exposed locations, access doors and hardware shall be designed to match doors and hardware for adjacent areas.
  - .7 SERVICE SPACE ACCESS: Access to any service space shall be provided to the appropriate service provider (i.e. Facilities Operations and Development, Medical Center Operations, regional campus facility maintenance provider, etc.)

### 00037. FURNITURE, FIXTURES AND EQUIPMENT (FF&E)

- .1 LEED POLICIES: The University promotes energy efficient green design, construction and building operations. Where possible, FF&E are to be selected and specified following the United States Green Building Council LEED (Leadership in Energy and Environmental Design) Green Building Rating System® consensus-based national standard for developing high-performance, sustainable buildings. Refer to the website: <http://www.usgbc.org>. This includes LEED for Commercial Interiors (LEED-CI) which addresses the specifics of tenant space in office, retail, and institutional buildings.
- .2 DESIGNS: The process of planning, design, specification and installation of FF&E is an integral part of the planning, design and construction of a project. The A/E and their team of specialists, including professional interior design services, shall be responsible for the planning, design and specification of all FF&E that is associated with a project. The University Project Manager will be responsible for directing and coordinating interior design services by the A/E.

The A/E shall provide ample seating (construction or fixed equipment) as part of the architectural design for corridors, lobbies and other areas immediately outside classrooms and other areas of assembly.

The A/E shall not design custom construction or millwork in places where there is a probability for equipment or function change as it increases future University costs for these changes. The A/E shall instead use flexible FF&E. Typical proposed substitutions are desks, counters and other office equipment areas. All proposals for custom construction or millwork are to be reviewed and approved by the University Architect prior to final development of the Construction Documents.

- .3 CATEGORIES: FF&E is categorized as Fixed Equipment or Movable Equipment. Refer to Division 10 SPECIALTIES, Division 11 EQUIPMENT and Division 12 FURNISHINGS for details.
  - .3.1 FIXED EQUIPMENT is generally defined as any manufactured product that is attached or requires significant structural or construction coordination in a building. Fixed Equipment is acquired through one or more of the construction contracts and is funded within the project construction budget. In some cases, the University may choose to purchase Fixed Equipment for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase. The Construction Documents must include all services and construction coordination for the installation of this equipment.

.3.2 MOVABLE EQUIPMENT is generally defined as any smaller, loose products that are acquired by the University. Movable Equipment purchases utilize a fund allocation within the total project funds but independent of the construction budget. Using specifications developed by the A/E, the University will procure movable equipment by means of a bid process or by using pre-bid University or State contracts.

.3.2.1 TECHNOLOGY EQUIPMENT: Technology equipment is a sub category of the Movable Equipment noted above. The cost of technology planning, design and specification for classrooms, auditoriums, and department classroom meeting space is also included in this budget. The University Project Manager will contract and oversee the technology design process.

The timing for technology design must coincide with the development of Construction Documents and prior to bidding. The A/E must be involved in this design as they are responsible for the coordination of all services, structural support, blocking, riser diagrams, power, data locations and required HVAC needs for the Equipment.

**Typically, movable equipment funding allocations are provided for new building construction projects but not for remodeling/renovation projects.**

00038. MISCELLANEOUS DESIGN REQUIREMENTS: The following requirements are of a general nature and do not fit into any particular CSI division. Requirements pertaining to particular materials or work are given in the appropriate CSI division in PARTS TWO, THREE, FOUR, and FIVE, of this Building Design Standard.

.1 TEMPORARY EGRESS: Building addition and expansion projects which involve eliminating or closing an existing required means of egress shall be provided with a temporary means of egress accessible to individuals with disabilities.

.2 STAIR DESIGN: Conform to applicable Ohio Building Code provisions.

.3 FLOOR LOADS: Design floor loads shall accommodate all live and dead loads including concentrated loads from fixed and movable equipment. Conform to the Ohio Building Code requirements, except that design live floor loads shall be at least 100 pounds per square foot. Identify floor live loads for each room or space on each floor plan drawing.

.4 LINES OF SIGHT INTO TOILETS shall positively be broken. Location of mirrors and reflected images shall be checked by the A/E. Direct or reflected sight lines into dressing rooms or toilets are prohibited.

.5 CORRIDOR DOORS: Doors on opposite sides of corridors shall be offset to prevent direct view from one room to another. Classroom and laboratory room doors opening into corridors shall be recessed the width of the door to eliminate corridor obstructions.

.6 RECESSES shall be provided for drinking fountains and telephones. The recesses shall be finished with glazed structural tile, ceramic tile, glazed concrete block, or concrete block finished with a paint which will withstand repeated scrubblings.

.7 EXTERIOR DOORS, except those designed with hardware for emergency exit only, shall be protected by canopies and wing walls; or, doors shall be recessed.

.8 HVAC IN REMODELING PROJECTS: Spaces between floor construction and suspended ceilings shall not be crowded with equipment of such size that the equipment cannot be

## DIVISION 0 PART 2: PROCESSING THE WORK

---

- serviced and effectively insulated for noise control. In lieu of such installations, properly insulated floor spaces, of a size which will accommodate equipment, shall be provided.
- .9 CONNECTION TO EXISTING UTILITIES: Refer to FACILITY SERVICES, Section 3, for instructions regarding design and installation of both temporary and permanent connections to existing utilities (i.e., steam, condensate return, heating hot water supply and return, chilled water supply and return, domestic hot water, gas, cold water, alarm systems, emergency electric, electric, etc.) Also see 01 51 00 and 33 00 00.
- .9.1 CONNECTIONS TO CITY OF COLUMBUS UTILITIES: In OSU campus peripheral areas where connections are being made directly to City of Columbus Utility Division water and sewer mains all City utility rules and ordinances shall apply. Expect system capacity charges, which are based on water line sizes, for domestic water, fire service lines, and sanitary sewer connections. Expect to have to run separate domestic water and fire suppression lines from the public right-of-way to the building. In addition there will be tap (inspection) fees and meter charges. If a building has been demolished on the site, credits will be applied based on the size of the previous services. The A/E shall as a part of the design process deal directly with the City Division of Water and Division of Sewerage and Drainage, presenting for their approval site utility drawings. Allow a number of weeks for this process. (Start as early as possible and don't expect special treatment for University projects). Any documents shared and/or approved by the City of Columbus shall be provided to the University Engineer. Construction Documents must make clear to the bidders what City fees and charges to anticipate as some of these charges may be significant.
- Before stormwater management plans are finalized for site drainage, including roof drains, the Stormwater Office of the City of Columbus Division of Sewerage and Drainage must approve them. Any approval documents from the City of Columbus shall be provided to the University Engineer. Flow control measures may be required. Meeting the requirements of the City may have unexpected financial impact so contact with the Stormwater Office must be made during the design development process.
- .9.2 CONNECTIONS TO UNIVERSITY WATER DISTRIBUTION SYSTEM: The Ohio State University master meters water from the City of Columbus Utilities Department. All City system capacity charges for water and sewer service have been satisfied for connections to the University water system. All the City requires, for record purposes, is a utility site plan showing water and sewer connections. This site plan shall be submitted to the OSU Facilities Operations and Development Utilities Division for transmittal at the bid document stage. The Utilities Division as part of the University's design approval process shall approve water and sewer tap locations. During construction a two-week notice to arrange utility outages is required as the outage may be disruptive to normal university functions. There are no tap (inspection) charges to the project for making connections; however, the contractor(s) will be expected to pay for Utilities Division staff time for utility outages to benefit the project. Water taps will be inspected by OSU Utilities Division and sewer taps by a civil engineer from Facilities Operations and Development.
- .10 ROOF-MOUNTED EQUIPMENT: Refer to BDS Divisions 21 – 28 FACILITY SERVICES – Document Requirements, FS-3.16 \_ \_ Roof-Mounted Equipment, Flashing and Roof Penetrations. Also note that pitch pans or pitch pockets are prohibited.
- .11 ROOF STRUCTURES AND ROOFTOP EQUIPMENT SCREENS: Finish materials and colors are subject to the approval of the University Architect.

## DIVISION 0 PART 2: PROCESSING THE WORK

---

- .12 WOMEN'S TOILET ROOMS: Increase the proportion of water closets and lavatories for women beyond OBC requirements. The number of water closets will vary according to specific projects, up to a fixture ratio of 1/3 men to 2/3 women for building populations where occupancy is expected to be split 50% men, 50% women for the next 20 years. Confirm this with the University Architect prior to schematic document review.
- .13 LACTATION ROOMS: All new and major renovated buildings will include at least one lactation room. Each facility will include - enough area to accommodate appropriate furniture (e.g. a lounge chair with tablet), counter space with sink, microwave, power and data outlets, and a Schlage L Series mortise indicator lock part # L9440 06N L283-722.
- .14 EMPLOYEE TOILET ROOMS: It is University policy to avoid providing separate toilet rooms for students and employees.
- .15 FAMILY OR ASSISTED-USE TOILET ROOM: Provide one family or assisted-use toilet (gender-neutral) room in all new buildings, and, when feasible, existing buildings. Room size shall meet ADA requirements with provisions for one water closet, one urinal, one lavatory and a diaper changing station. Location should be adjacent to either entrance or elevator lobby on the ground floor.
- .16 PROVISION FOR ADDITIONAL FLOORS: All structures must be designed to accommodate the addition of two floors in the future unless this requirement is waived by The University Architect. Notations on the structural and foundation drawings must show allowable future loadings.
- .17 University facilities are intended to last as long as the university. Therefore buildings and structures should be designed last beyond 100 years.
  - .17.1 Some facilities, such as barns and other temporary structures, are not required to be designed to last beyond 100 years. However, the A/E shall ensure that the structure will last its intended/design life span.

### **00040. PREPARATION OF DOCUMENTS**

- 00041. DRAWINGS AND PROJECT MANUAL shall be prepared in conformance with Section 153.50 and 153.52 of the Ohio Revised Code. The Ohio State University requires separate documents to be prepared for each of the following: General; Plumbing; HVAC (Heating, Ventilating, and Air Conditioning); Fire Protection; and Electrical.

As a flagship institution, The Ohio State University recognizes its responsibility to provide sustainability leadership by adopting business practices that reduces energy consumption. Therefore the Green Build and Energy policy [\\_available on the Project Delivery website: http://fod.osu.edu/project-delivery/](http://fod.osu.edu/project-delivery/), has been developed and shall be incorporated into the building process as applicable.

Drawings and Project Manual documents shall follow all applicable guidelines as referenced in the Electronic Drawing Naming Requirements: [http://www.fod.osu.edu/sites/default/files/Electronic\\_Drawing\\_Naming\\_Req.doc](http://www.fod.osu.edu/sites/default/files/Electronic_Drawing_Naming_Req.doc) available on the Project Delivery Website: [fod.osu.edu/project-delivery/](http://fod.osu.edu/project-delivery/)

The A/E is required to submit a completed Design Review Acceptance form, available on the Project Delivery Website: [fod.osu.edu/project-delivery/](http://fod.osu.edu/project-delivery/), for every phase of the project.

- .1 MATERIALS: Schematic sketches and drawings may be prepared electronically and presented on tracing paper, and submitted on bond paper for review. Design development

## DIVISION 0 PART 2: PROCESSING THE WORK

---

- drawings may be prepared electronically and presented on tracing paper, submitted on bond paper for review.
- .2 SHEET SIZES: The 36 by 24 inch size is preferred. Authorization must be obtained from the University Architect for use of other sheet sizes.
- .3 COVER SHEETS, properly identified as to which submittal is being made, shall be provided on each submittal of drawings. Cover sheets for schematic, design development, and construction document submittals may be made on paper.; The project numbers assigned by the University shall appear on cover sheets. See 00022.3 for code information to be included on the drawing cover sheet. Obtain sample sheet from University Project Manager. See Appendix F for examples of desired Title Sheet.
- .4 SIGNATURE SPACES shall be provided on the cover sheet for each submittal. The University Project Manager will obtain the required signatures. For construction documents, the University Project Manager will return the signed cover sheet to the A/E prior to the printing of bid sets.
- .4.1 PROJECTS PRESENTED ON NOT MORE THAN FIVE DRAWING sheets may be presented with the project title on sheet 1. A space for signatures must be provided on EACH of the five sheets.
- .5 TITLE BLOCKS shall be drawn in the lower right-hand corner of each drawing sheet. The project number, assigned by the University, in addition to the A/E's job number, shall appear in the title blocks. See Appendix F for example of desired title block.
- .6 SHEET NUMBERS: Use P, H, F, E, etc. Do not use "M" (Mechanical) for Plumbing, HVAC, or Fire Protection.
- .7 DRAWINGS FOR REMODELING PROJECTS: Two drawings of each floor plan are required: One drawing is to show existing construction and demolition; the second is to show the new construction and existing construction which is to remain. When sheet size permits, the two plans shall be drawn on the same sheet, for easy comparison of the two. This requirement applies to the floor plans for all submittals and all divisions of the work. Show existing room numbers on the demolition drawings.
- .8 ROOM NUMBERS: On schematic drawings, identify rooms and other areas by the nomenclature and numbers indicated in the Program of Requirements. After numbers have been assigned by Facility Planning, Facilities Operations and Development, the assigned numbers become the permanent numbers and shall be used when making references to spaces, in notes on the drawings, in schedules, and in correspondence.
- .9 CORRIDORS, VESTIBULES, AND OTHER AREAS AND SPACES
- .9.1 CORRIDORS, VESTIBULES, AND OTHER AREAS AND SPACES which have not been assigned numbers by the University may be assigned numbers by the A/E to suit its needs for completing room finish schedules and for use in reference notes and correspondence. These numbers are not to be considered as permanent numbers. Refer to SIGNAGE in Division 10 of these guides.

### 00042. PROJECT MANUAL:

- .1 PRINTING AND BINDING: The A/E is advised to run only the number of copies required for review purposes. SETS FOR BIDDING PURPOSES SHOULD BE MADE ONLY AFTER ALL REVIEW CORRECTIONS HAVE BEEN MADE. Generally, follow instructions in the Ohio Facilities Construction Manual.



- .1.2 COVER SHEETS
  - .1.2.1 The University Project Manager will furnish sample printed front covers for the construction document Project Manual. The A/E shall duplicate the paper quality, printing colors, styles and format, fill in all required titles, names, information and shall provide matching back covers of the same size paper quality and color as the front cover samples. In binding the finished books, both front and back covers shall be doubled at the binding edge and folded over screw-post type fasteners.
- .1.3 BINDERS: Screw-type binding posts are required. For schematic and design development submittals, these binders may be exposed; for construction document submittals, any binder used must be covered as indicated above. Roll-form plastic binders and ACCO clips are prohibited.
- .2 OUTLINE PROJECT MANUAL: Submit outline of Division 00 and the specifications with schematic drawings; update this Project Manual for submission with design development drawings.
  - .2.1 Outline specifications are among the most important documents to be submitted. It is by these specifications that the University Planning Committee determines the acceptability of material and construction proposed by the A/E.
  - .2.2 Outline specifications should contain a brief, complete description of the entire project and should explain how the total work will be accomplished.
  - .2.3 The technical sections should be in outline form to serve as a guide in writing the construction document specifications. Information contained in these sections should be concise, but must name the materials, give locations (since the drawings, at this time, are not developed to the point that locations of materials are shown), indicate method of construction or installation, and indicate the finish of the completed installation.
    - .2.3.1 DO NOT write lengthy installation details and DO NOT write outline specifications as though instructing a contractor what to furnish and how to install the specified materials; save these details for the construction documents. Use of the past participle form of verbs to describe materials in place is preferred. Terse sentences, clauses, or phrases should be used as in the following example: "Corridor Partitions: Full height construction, 8x8x16-inch non-load-bearing concrete units laid in running bond with type N mortar.
- .3 CONSTRUCTION DOCUMENT PROJECT MANUAL:
  - .3.1 SOLICITATION: Follow sample form provided by the Contract Administrator. . The time for receipt of bids will be established by the University in cooperation with the University Architect. All copies issued must show this information. Charges for the non-refundable cost of documents will be as stated in the SOLICITATION.
  - .3.2 DIVISION 00 DOCUMENTS: Obtain the most recent edition from the Contracts Administrator. Refer to the Table of Contents for proper order.

.3.3 NUMBERING OF ITEMS: In order to distinguish CSI divisions in the specifications from divisions of the work, use Arabic numerals for CSI divisions.

.3.4 WAGE RATES: Wage rates shall be bound into each set of Project Manuals as a part of the General Conditions.

.3.5 SUPPLEMENTARY CONDITIONS: The A/E is cautioned to study the General Conditions plus Supplementary Conditions before beginning the preparation of Project Manual and to refer to them constantly throughout the writing of specifications. Particular attention should be paid to standardized or computerized specifications written by outside firms, who are employed to write technical sections, to ascertain that nothing contained in those specifications disagrees with provisions in the General Conditions or these supplements. Complete coordination of all Construction Documents is the responsibility of the A/E.

.3.5.1 ARTICLES WHICH REQUIRE SPECIAL ATTENTION

ART. 4 DEFINITIONS, ITEM 4: The A/E shall name itself and shall list its business address.

ART. 5 CUTTING AND PATCHING: A/E to make certain that cutting and patching instructions are consistent.

ART. 12 PROJECT SIGN: Signs are required. Specifications for the sign should be made a part of the section entitled TEMPORARY FACILITIES.

ART. 14 GUARANTEE/WARRANTY: There are exceptions to the one year guarantee period. Items for which longer guarantee periods are required are indicated in PART TWO of these guides. The University Architect will indicate any other portions of the work on which a longer guarantee period is desired.

.3.6 GENERAL CONDITIONS:

.3.6.1 ARTICLES WHICH MAY REQUIRE SPECIAL ATTENTION

SHOP DRAWINGS: Explicit instructions for these submittals, as well as for submittals of samples, if different, should be given in the section entitled SAMPLES AND SHOP DRAWINGS in Division 01.

CLEANING UP: Additions and modifications to this article, if lengthy, should be made in the section entitled CLEANING UP in Division 01.

JOB MEETINGS: Detailed instructions, if different, for scheduling meetings, keeping of records, and distribution of minutes of such meetings should be given in the section entitled SCHEDULES AND REPORTS in Division 01. In writing this section, amplify the provisions stated but DO NOT change the intent of the article.

PAYROLL SUBMITTALS AND WAGE DETERMINATION: For projects in which Federal funds are involved, wage scales must be obtained from the U.S. Department of Labor. For State projects, wage scales must be obtained from the State of Ohio, Department of Commerce, Industrial Compliance Division. Ascertain, from the date on the wage scales received, that the schedule of wages will be applicable during the bidding period. Update the schedule by addenda, as required during the bidding period.

.3.7 TECHNICAL SECTIONS:

.3.7.1 SPECIFICATION FORMAT: The division numbers used in PART FOUR of this publication generally conforms to the Construction Specifications Institute Masterformat 2004.

.3.7.2 NUMBERING SYSTEM: Division numbers used in preparation of specifications shall generally conform to the CSI Format. Section numbers may be as listed in the format or sections may be numbered consecutively by either the number or the letter designations. Within the sections, the A/E may, as he chooses, use a decimal numbering system, as used in this publication, or an alphanumerical system to designate articles, paragraphs, and subparagraphs. Do not number each line. Written material shall be organized within each article so that related thoughts are grouped under one designation, either a number or a letter, in logical sequence. DO NOT number or letter each separate sentence or thought.

.3.7.3 MATERIALS AND EQUIPMENT: Specify by performance specifications or by manufacturers' model numbers. If manufacturers' model numbers are used, name three or more manufacturers whose products are equal or superior in:

Appearance	Function
Quality	Operation
Design	Service Life

State that the drawings and specifications are based on the first product named and that the contractor must make all changes required to accommodate products of other manufacturers. The A/E is responsible for insuring that all brands specified are compatible with the basic building design insofar as size, weight, and services and that brands specified are truly equal or superior in properties listed above.

.3.7.4 COMPUTERIZED OR STANDARDIZED SPECIFICATIONS:

The A/E is cautioned that computerized specifications must be edited to suit the requirements of the project being specified. The plea that this mandatory editing and rewording of the A/E's "standard" specifications will result in excessive costs or delays in producing the construction document submittals will not be considered as warranting publication of a specification which does not fit the work. Computerized specifications must be printed on letter size paper.

.3.7.5 PROHIBITED WORDAGE: The following words, phrases, and clauses are expressly prohibited:

.3.7.5.1 The note "by others". These words must not be used, either on the drawings or in the specifications. In lieu of these words, name the specific contractor or agent.

.3.7.5.2 The word "Owner". The State is the owner of a project under construction and remains the owner until completion or later, when the University becomes the owner. Since the University becomes the ultimate owner, use the word "University" in lieu of "Owner".

## DIVISION 0 PART 2: PROCESSING THE WORK

---

- .3.7 .5.3 The words “Using Agency” or “User”. The University Architect acts in behalf of ALL University agencies including the using agency to see that requirements of the University are satisfied. The A/E is responsible only to the University Architect, not to the “using agency”, “user”, or other University agencies.
- .3.7 .5.4 The words “This Contractor shall . . .” to begin instructions to a contractor. These words are redundant since instructions are directed to a single prime contractor and it should be obvious to which contractor the instructions are directed.
- .3.7 .5.5 The words “alternate” or “substitute” to indicate an “option”. The word “alternate” should be used only for alternative work which is specified in the technical sections of the specifications and must be included in the bidders’ proposals. The word “option” should be used to indicate items for which the contractor may make a choice without affecting the contract.
- .3.7 .5.6 The word “mechanical” when referring to the Plumbing Contract, the Fire Protection Contract, or the HVAC Contract, or when referring to any of the contractors for these divisions of the work. The applicable word “plumbing”, “fire protection”, or “heating, ventilating, and air conditioning” must be used when making these references. On drawings, avoid using “mechanical” to describe pipe or duct chases, HVAC equipment rooms, electric equipment rooms, etc.
- .3.7 .5.7 The words “comparable” or “equal” or “similar.” Be specific.
- .3.7 .5.8 The phrase “latest edition” when referring to a code or any trade, technical, federal, military, or other “standard” specification is prohibited. The A/E must list the code or standard by name and number and indicate the date of the edition, as well as the latest revisions thereto. Referenced dates must be those in effect at time of plan approval.

END OF PROCESSING THE WORK

## **DIVISION 01 – GENERAL REQUIREMENTS**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **PART TWO PROVISIONS FOR CONTRACT ADMINISTRATION**

#### **01 00 00. GENERAL REQUIREMENTS**

#### **01 11 00. SUMMARY OF THE WORK**

01 11 13. A GENERAL DESCRIPTION of all elements of the project, including exterior work and any other related work, is required. This description, though brief, should be complete enough to indicate the full scope of work in each contract so that prospective bidders can decide whether or not they wish to bid on the project. The use for which the project is being built should be explained. Some parts of this description can be copied from the Program of Requirements.

01 11 16. ITEMS FURNISHED BY THE UNIVERSITY: If the University furnishes items to be installed by any of the contractors, list the items and briefly indicate the work required of each contractor. Do not give detailed installation instructions; save details for the applicable section of the specifications.

#### **01 12 00. MULTIPLE CONTRACT SUMMARY**

01 12 13. LIST THE SEPARATE CONTRACTS under which the work will be accomplished and outline the scope of work included in each contract. Generally, there will be four separate contracts on major projects: General Construction, Plumbing, HVAC, and Electrical. Combine Fire Protection work with Plumbing. Consult the University Architect regarding desirability of separate contracts for Landscaping, Specialized Equipment, Carpet, Laboratory Equipment, Theater Equipment, Temperature Controls, and other work.

01 12 19. WORK ON OTHER PROJECTS: If other work, outside the scope of contracts for this project, will be performed simultaneously with the work on this project, explain how contractors must cooperate with outside contractors and with the University to avoid interference with each other's work.

01 14 00. WORK RESTRICTIONS: Fully describe all job conditions that will affect phasing and scheduling of the work. Particular attention must be given to scheduling remodeling work in buildings that will remain in operation during remodeling. Examples of some problems encountered are:

- .1 PROVIDING AND MAINTAINING MEANS OF INGRESS AND EGRESS: Temporary entrances and exits must meet code requirements.
- .2 MAINTAINING SECURITY: Areas that are being operated by the Using Agency must be secured from the construction area and vice versa.
- .3 USE OF DOCKING FACILITIES: Sometimes these facilities must be shared between the University and the contractors.
- .4 STORING OF CONSTRUCTION MATERIALS: If adequate areas cannot be provided, delivery schedules will be affected.

## DIVISION 01 GENERAL REQUIREMENTS

---

- .5 SCHEDULING FOR MOVES BY THE USING AGENCY: If remodeled spaces must be ready for use or vacated by certain dates, name the spaces and give the dates.
- .6 MAINTAINING SERVICES: These requirements should be detailed in the section entitled, TEMPORARY FACILITIES AND CONTROLS.
- .7 DUST CONTROL AND NOISE CONTROL: Temporary partitions required for control of dust and noise should be shown on the drawings. Construction of these partitions may be specified in the section entitled, TEMPORARY FACILITIES AND CONTROLS or in the section in which the partition materials are specified. Refer to paragraph 01 56 16. of these guides.

### **01 21 00. ALLOWANCES**

- .1 RESTRICTED USE: Allowances are generally prohibited, however, if circumstances warrant, the University Architect will approve the use of allowances for certain items.
- 01 21 16. CONTINGENCY ALLOWANCE FOR HARDWARE: Refer to Division 08.

### **01 23 00. ALTERNATES**

- 01 23 01. TITLE OF SECTION FOR SPECIFICATIONS: Although the CSI format also lists this title as "ALTERNATIVES", it is required that the title, "ALTERNATES" be used in order to be consistent with State documents in which the word "alternate" is used.
- .1 DEFINITION: Refer to paragraph 0042.3.6.5.5 for instructions in use of the word "alternate".
- 01 23 02. PURPOSE OF ALTERNATES: A limited number of alternates may be used as a means of ensuring base bids within the available construction funds. The Architect/Engineer (A/E) shall consult the University Architect regarding priority of alternates. Additive alternates shall be used in preference to deductive alternates. See 00013.2.
- 01 23 03. DESIGNATIONS for alternates shall be:  
G-1, G-2, etc. for the General Contract.  
P-1, P-2, etc. for the Plumbing Contract.  
H-1, H-2, etc. for the Heating, Ventilating, and Air Conditioning Contract. (Do not use the letter "M" to designate this series.)  
E-1, E-2, etc. for the Electric Contract.
- Alternates for other separate contracts should be listed by consecutive numbers prefixed by the letters used on the drawings to designate the contract.
- 01 23 04. COORDINATION OF ALTERNATES: Care must be exercised to coordinate Plumbing, HVAC, and Electrical alternates with General Contract alternates, with each other, and to list alternates in consecutive order; when possible, alternates

which are contingent upon one another should be given the same number, as: G-2, P-2, H-2, and E-2. Awards of alternates must be in priority sequence. Therefore, Alternate 1 is priority 1; Alternate 2 is priority 2; etc.

**01 31 00. PROJECT MANAGEMENT AND COORDINATION**

**01 31 19. PROJECT MEETINGS**

- .1 **PRECONSTRUCTION MEETING:** The University will schedule and furnish the agenda for a preconstruction meeting after award of contract; attendance will be required for the A/E and successful bidders. Among items to be discussed are provisions specified in this division of the specifications.
- .2 **PROGRESS MEETING:** Include the following in the specifications; edit and revise to suit job conditions. The General Contractor shall schedule a weekly job progress meeting with other prime contractors and major subcontractors and shall notify the A/E of the time and place of the meeting. Subsequent meetings shall be held on the same day and hour of the week for the duration of the construction period; except, upon instructions of the A/E, the scheduled meetings may be increased or decreased as required by the progress of the work. Notes shall be taken by the A/E on discussions and decisions made at each meeting. Typed copies of the notes shall be distributed to all concerned parties; two copies shall be furnished to the University Architect.

**01 32 00. CONSTRUCTION PROGRESS DOCUMENTATION**

- 01 32 33. **CONSTRUCTION PHOTOGRAPHS:** The A/E shall furnish digital photographs that show progress, work that is concealed, problem areas, etc. Each photograph shall be identified with: project name, exact location (such as Footing for Column B-9) and the orientation of the photograph. Electronic file naming should be consistent with the identification requirements for each photograph. At the completion of the project the A/E shall provide the university with a CD containing all construction photographs filed by date having file names that clearly identify each photograph and location.

**01 33 00. SUBMITTAL PROCEDURES**

- .1 **CONSTRUCTION SCHEDULE:** Include the following paragraph (or a paragraph similarly worded) in the specifications: The final schedule, bearing the approval signature of all prime contractors, shall be submitted in quadruplicate to the A/E Following approval by the University, copies of the final schedule shall be distributed to all interested parties. Tentative dates for interruption of utility services shall be incorporated.
- .2 **PROJECT INSPECTION REPORTS:** Instruction for preparation and submittal of these reports will be given at the preconstruction meeting.

## DIVISION 01 GENERAL REQUIREMENTS

---

01 33 13. CERTIFICATION REQUIRED FROM SUPPLIERS AND INSTALLERS: The following is a list of certifications and other submittals required, in addition to guarantees, to assure quality materials or workmanship, or both. For some of these requirements, correct wording of articles, to be incorporated in the technical sections, is provided in these guides. Also see 01 70 00.

### .1 GENERAL CONSTRUCTION:

Sewers	- Test approvals from City of Columbus or other controlling governmental agency
Reinforcing steel	- Mill certificate
Insulating concrete	- Manufacturer's certificate roof decks
Structural steel	- Erector's affidavit frame
Face Bricks	- Results of efflorescence tests
Masonry Restoration	- Experience record of contractor or subcontractor doing the work
Steel joists	- Manufacturer's certificate
Metal decking	- Manufacturer's certificate
Sealants	- Experience record of contractor or subcontractor doing the work
Metal Windows	- Performance reports
Reflective	- Performance reports insulating glass
Finish Hardware	- Inspection by an Architectural Hardware Consultant
Fire-rated ceiling	- Certification by installer
Carpeting materials	- Test reports and manufacturer's certificate
Non-standard	- Test reports and resilient floor manufacturer's certificate materials
Painting	- Statements by paint manufacturer and applicator
Fire-resistive	- Manufacturer's certificate coatings
Laboratory equipment*	- Financial statement of manufacturer, experience qualifications
Library equipment*	- Financial statement of manufacturer, experience qualifications
Kitchen equipment*	- Financial statement of manufacturer, experience and qualifications
Radiation protection	- Qualifications of installer
Elevators	- Maintenance Service, certificate of Inspection

\* Laboratory Equipment, Library Equipment, and Kitchen Equipment will be included in General Contract unless directed otherwise by the University Architect.

### .2 PLUMBING:

Soil, waste, and vent piping	- Inspection certificate
Underground service piping	- Test reports
Interior piping	- Test reports
Welders	- Copy of certification



## DIVISION 01 GENERAL REQUIREMENTS

---

- Water lines - Sterilization test report
- Gas service and interior piping - Test reports and recording line charts for purging and pressure
- Gas distribution lines - Training certifications for all covered tasks performed, pressure test charts, material test records

### .3 FIRE PROTECTIONS:

- Fire department - Certification that pipe threads and connections are suitable for use with local hydrants and fire department equipment
- Inspection - National Automatic Sprinkler agreement and Fire Control Association standard inspection and maintenance form
- Fire lines and fire pumps - Test reports
- Welders - Copy of certification
- System - Fire Marshal's certification of inspection and acceptance

### .4 HEATING, VENTILATING, AND AIR CONDITIONING:

- Balancing of air and water systems - Balance reports
- Boilers - Tests for safety and function, inspection and other certificates
- Refrigerant lines - Proof of testing in compliance with USASI Standard, and reports
- Fan ratings - Test performance seals, performance curves
- Air, water, and steam lines - Test reports, weld NDT reports, hydro reports
- Welders - Copy of certification, copy of procedure certification.
- Chilled water - Pressure and weld /fusion test records, water treatment report, material test records

### .5 ELECTRIC:

- Primary cable installations - Testing per Division 33
- Cable splicing - proof of skill requirements per Division 33

## DIVISION 01 GENERAL REQUIREMENTS

---

- 01 33 23. **SHOP DRAWINGS AND SAMPLES:** A separate section is required. This section should be written to include submittals for all prime contracts so that no separate section or article need be written in the specifications for these contractors; however, each section in the technical provisions should contain a reference to this section together with a list of items for which shop drawings or samples are required. Additionally, this section should specify a reasonable timeframe, based on contract date and project timeline, to ensure that submittals are submitted and reviewed minimizing schedule impacts. Attention should be called to the fact that this section is a supplement to the General Conditions. Require that a handwritten signature of the contractor is required, in addition to their stamp of approval.
- .1 **DRAWINGS REQUIRING CHECKING BY CONSULTANTS:** The A/E shall determine the requirements for submittal of drawings pertaining to work done by consultants and shall stipulate the number of copies required; two copies of approved drawings are required for resubmittal to the University.
- .2 **SAMPLES:** After consultation with the University Architect, the A/E shall indicate the items for which samples are required and shall stipulate the number of each required. Samples and color chips must be approved by the University Architect.
- .2.1 **SAMPLES FOR INCLUSION IN THE WORK:** If samples are expensive or are complete assemblies suitable for inclusion in the work, e.g., precast concrete panels, locksets and door closers, laboratory or other equipment, state that approved samples may be installed in the work, provided the location of these items is made known to the A/E.
- .3 **MODELS AND PATTERNS:** Specifications for ornamental work which requires models or patterns, shall specifically stipulate that models and patterns become the property of the University after the ornamental work has been installed.

### **01 35 00. SPECIAL PROCEDURES**

- 01 35 23. **OWNER SAFETY REQUIREMENTS:** To ensure student, faculty, staff and visitor safety and the continuity of University services, each construction project shall review construction risks (see FOD Construction Risk Assessment Process Guidelines at [fod.osu.edu](http://fod.osu.edu). Once on the website, do a file search with the name of the documents by clicking the search magnifying-glass icon at the upper right hand corner of the screen). If enhanced risk mitigation requirements are identified, they shall be specified and may include components like 1) Enhanced Emergency Call List, 2) Utility shut off plan, 3) Enhanced Excavation Permit 4) Stock repair parts.
- 01 35 43. **HAZARDOUS MATERIALS PROCEDURES:** Refer to Appendix V for information regarding hazardous materials. The University Architect shall be notified **IMMEDIATELY** of Contractor's intent to handle materials that are considered hazardous such as asbestos, mercury, flammable fuels, explosive chemicals, PCBs, etc.

**01 40 00 RECYCLING OF CONSTRUCTION / DEMOLITION WASTE:** The General Contractor is responsible for construction/demolition waste recycling on the job site. The University requires any project with a total cost above 1 million dollars to have a recycling Waste Management Plan that encompasses the University goal of diverting a minimum of 50% (by weight or volume) of construction/demolition waste from a landfill. The Contractor is responsible for submitting the waste management plan to the University Project Manager prior to implementing the plan. A final report shall be submitted to the Project Manager at the completion of the project and shall indicate how much construction waste has been diverted to recycling by weight or volume and also the amount of waste that was delivered to the landfill. Contractor shall include dates, weight tickets, receipts & invoices in final submittal. For more detailed information and available forms please visit: <http://www.fod.osu.edu/resources>.

**01 45 00. QUALITY CONTROL**

01 45 10. **SERVICES BY SPECIALISTS:** In addition to the field supervision and inspections required by the A/E's contract and by State agencies, the following services by specialists will be required on major projects. Fees for specialists' services will be handled by the A/E as a reimbursable expense. While these services will be performed, the A/E shall supervise the specified operations; the specialist shall furnish required reports directly to the A/E, the State Architect and the University Architect. Details of the type of services required, methods of investigation, frequency of investigations or tests, number and type of reports required, and method of payment for specialists' services shall be included in the applicable technical sections of the specifications. Unless expressly exempted by the University, the following services shall be performed by qualified independent testing agencies:

.1 **GENERAL CONSTRUCTION:**

- Soils compaction tests
- Piling and caissons, inspections and tests
- Concrete sampling and tests
- Sound transmission tests
- Radiation testing

.2 **PLUMBING CONSTRUCTION:**

- Supervision of purging of gas piping
- Sterilization of water piping
- Testing of completed installations prior to inspection by the State Fire Marshal or his designated representative.

.3 **HVAC CONSTRUCTION:**

- Systems balancing
- Soil corrosion analysis for cathodic protection
- Pressure test for leaks by gas utility company
- Pressure test, weld inspection per applicable codes for steam, heating hot water, condensate, etc.

Pressure test, weld/fusion inspection per applicable codes for chilled water

.4 ELECTRIC CONSTRUCTION:

Testing of communications systems

Testing of signaling systems

Testing of fire protection equipment and alarm system

Testing of Distributed Generation safety systems to prevent unsafe parallel operation

.5 SPECIALIZED SYSTEMS:

Cranes and lifting systems: load test and certified inspection

**01 50 00. TEMPORARY FACILITIES AND CONTROLS** – Note overlapping of Special Conditions and Division 01 in State Architect's Handbook.

.1 ACCESS TO FACILITIES: While The Ohio State University is a publicly owned institution, its function and facilities are dedicated to serve specific operations and programs. Therefore, contractor personnel may be barred from using existing toilet, food service, or other facilities.

.2 UTILIZATION OF EXISTING HVAC EQUIPMENT DURING CONSTRUCTION: The utilization of existing HVAC equipment for temporary heating and cooling during construction requires written approval from the University Engineer. It is the A/E's responsibility to determine if this is necessary prior to the final CD submittal and all details for use shall be included in the CD phase documents. If equipment is approved for use during construction it is the Contractor's responsibility to completely maintain the equipment during construction and submit written reports to the Project Manager to show that maintenance has been performed. The Contractor shall provide filters for air handling units with a minimum efficiency of 30% prior to construction and shall perform proper cleaning of equipment after construction is complete. Contractor shall replace filters with new after construction is complete and verify that all equipment is in proper working condition. If repairs are required it is the Contractor's responsibility to perform those repairs. If approval is not granted by the University Engineer then it is the A/E's responsibility to provide instructions to the appropriate Prime Contractor in the Bid Documents of alternative means for temporary heating & cooling.

.3 UTILIZATION OF NEW HVAC EQUIPMENT DURING CONSTRUCTION: The Utilization of new HVAC equipment for temporary heating and cooling during construction requires written approval from the University Engineer. If approval is granted the A/E must provide the following requirements to the appropriate Prime Contractor in the Bid Documents.

.3.1 One year Contractor labor and material warranty on equipment starts after the Certification of Contract Completion has been issued by the Contracting Authority.

.3.2 One year Factory Warranty, or the extended Warranty Period as indicated in the Project Manual, on equipment starts after the Certification of Contract Completion has been issued by the Contracting Authority.

.3.3 Contractor is responsible for proper maintenance and cleaning of the equipment during construction and providing the entire HVAC system in “like new” condition before receipt of the Certification of Contract Completion. Any damages or repairs of the equipment during construction are the responsibility of the Contractor.

01 51 00. TEMPORARY UTILITIES: Requirements are generally as stated in the General Conditions with modifications regarding payment for water, fuel, and power consumed. Contractors must arrange for and pay for all temporary utilities required for execution of the work. Specifications shall be written to stress this point. The Ohio State University owns and operates the utilities throughout most of the Columbus campus. Peripheral areas and regional campus buildings may have service connections directly from the public utilities. The A/E will determine type and scope of each utility needed during construction document phase and, after discussion with The Department of Facilities Operations and Development, provide engineering and specific direction (including metering) to the contractors in the project specifications and on the drawings regarding the arrangement for such utilities. **Note: stating to provide temporary service will not be acceptable**

.1 UTILITY COMPANY INSTALLATIONS: Plans for running temporary lines through University property shall be reviewed by the A/E in conference with the University Engineer and FOD Utilities.

.2 CONNECTIONS TO EXISTING UTILITIES: If connections to University utilities are permitted, the A/E shall obtain drawings of existing utilities and shall consult the University Engineer and FOD Utilities regarding services available and points of connections to services. All services shall be metered through meters furnished by the contractors and the University shall be reimbursed for water, fuel, and power consumed. The specifications shall contain instructions to the contractors to make requests for these services through the University Engineer and by completing the form, UTILITY SERVICE REQUEST <http://www.fod.ohio-state.edu/sites/default/files/request.doc> obtained from The Department of Facilities Operations and Development, 2003 Millikin Road, Columbus, Ohio 43210.

**OARDC:** A request to mark OARDC utility locations will be made by the Contractor by calling the OARDC Facilities Service Department at 330-263-3915. Contractor’s name and phone number; the name of the person making the request; the project name and number; location of the area to be marked and the name of the Project Manager will be provided. After receipt of this information a work order will be issued. The utilities will be marked within 72 hours of the call, excluding weekends and University holidays. All costs shall be borne by the Contractor. For those are public utilities on and around the OARDC campus that may not be known to and will not be marked by University personnel. Contact the Ohio Utility Protection Service (811 or 1-800-362-2764; <http://www.oups.org>) for the location of these public utilities.

**OARDC:** There is no cost for use of water and/or electricity related to the project execution.

- .2.1 Temporary connections to the OSU primary electrical distribution system (construction power) shall meet the applicable sections of Division 33 and the FOD Primary Electric Service Policy (found at [https://fod.osu.edu/sites/default/files/primary\\_electrical\\_service.pdf](https://fod.osu.edu/sites/default/files/primary_electrical_service.pdf)) and subject to the associated inspection requirements of the Primary Service Connect Checklist(found at [https://www.osu.edu/sites/default/files/primary\\_electrical\\_service\\_construction\\_power.pdf](https://www.osu.edu/sites/default/files/primary_electrical_service_construction_power.pdf))

**OARDC :** The interruption, disconnection, reconnection, reduction or curtailment of any existing services shall not be undertaken without minimum prior notice of two (2) weeks and shall be coordinated with the OARDC Facilities Services Department at 330-263-3915. This work may be performed during normal working hours, holidays and weekends or as directed by the Facilities Services Department, but shall always be scheduled to minimize the effect of these shutdowns with other facilities on campus.

The appropriate Contractor involved with the utility shutdown shall, at the beginning of the construction period, enter into a contract with the OARDC Facilities Services Department for this work. The appropriate Contractor shall determine the number of times, the types and length of shutdown required for connections to that utility. Costs, if any, shall be borne by the Contractor.

- .2.2 Temporary connections to the OSU domestic water system, including fire hydrants, shall be approved by FOD Utilities (292-6383 or 292-3428). Hose connections to fire hydrants are prohibited between October 15 and April 15 unless special arrangements for freeze protection have been approved by FOD Utilities.
- .2.3 The use of HVAC systems during building finishing activities shall require inspection and commissioning of mechanical system components, metering and controls equipment. FOD Utilities shall approve the use of steam and/or chilled water to HVAC systems supplied from FOD's central/regional steam and/or chilled water plants,
- .3 **COST:** Costs for providing temporary services shall be included in the contractors' bids. Specifications shall clearly identify each contractor's responsibility for the installation of service lines and payment for services, whether services are furnished by the utility company or by the University.
- .3.1 **GENERAL CONTRACTOR** shall pay for water, steam, fuel for heat, and electric power consumed.
- .3.2 **PLUMBING CONTRACTOR** shall install and maintain water supply lines and make changes in lines as necessitated by conditions at the site.
- .3.3 **HVAC CONTRACTOR** shall install and maintain heating systems and make changes as required.

## DIVISION 01 GENERAL REQUIREMENTS

---

.3.4 ELECTRICAL CONTRACTOR shall install and maintain electrical installations and make changes as required.

.4 DURATION OF SERVICES: The specifications shall clearly identify each contractor's responsibility for providing continuous utility services until date of final acceptance or beneficial occupancy (whichever comes first) including operation of permanent equipment and services.

### **01 52 00. CONSTRUCTION FACILITIES:**

01 52 13. FIELD OFFICES AND SHEDS: Each prime contractor shall provide and maintain a clean, weather tight office at the site suitable for his own use, and for use of his subcontractors. All expenses including the installation cost, and the use of telephone, heat, light, water, and janitor service shall be borne by the contractor.

.1 GENERAL CONTRACTOR'S OFFICE shall be of size suitable for the use of the contractor, his subcontractors, the Office of Facilities Planning and Development's Project Captain, and the A/E's representative. Office shall be heated, lighted, have doors with locks, and private line telephone service. One space in the office shall be provided for use of the A/E's representative; space shall be equipped with plan table, filing cabinet, and telephone. The General Contractor or his authorized agent shall be present at the office, or elsewhere on the site, at all times while the work is in progress.

### **01 54 00. CONSTRUCTION AIDS**

01 54 13. TEMPORARY ELEVATORS:

.1 ONE NEW ELEVATOR may be used for construction purposes. Facilities shall be made available to all contractors and subcontractors; all costs associated with use shall be assigned to the General Contractor. Written arrangements must be made with the University Architect and must include:

Installation of protective covering of car interior, doors and entrance.

Weekly cleaning and servicing by the elevator installer at the Contractor's expense.

Complete restoration of all elevator system components to like new condition ready for turnover to OSU.

The repair and warranty period required by the contract will not be diminished by authorizing this use.

.2 EXISTING ELEVATORS shall not be used during construction without permission of the University Architect. Refer to Division 14 for conditions governing this use.

.3 PROTECTIVE PADS and hooks for hanging the removable pads shall be furnished and installed in the elevator which is most suitable for furniture and equipment moving for use by the University.

01 54 16. TEMPORARY HOISTS:

- .1 HOISTS: Specify that the General Contractor furnish hoisting facilities and that these facilities be made available to other contractors and to subcontractors. Other prime contractors may furnish facilities to suit their needs if suitable arrangements cannot be made with the General Contractor. Provide for hoisting of workers as well as materials and equipment if it will be cost effective.

**01 55 00. VEHICULAR ACCESS AND PARKING**

- .1 CONSTRUCTION AREA MAINTENANCE AND ACCESS: If existing streets and roads on campus must be used, a detailed plan of the routes to be used must be worked out in cooperation with University personnel. The final approved plan shall be shown on the project drawings, and specifications must stipulate that no other streets and roads be used.
- .2 CLEAN-UP ENFORCEMENT: Specifications shall contain provisions that Contractors must remove mud and spillage from public and university streets without delay. Failure to clean streets promptly could result in streets being cleaned by the University or other public agency at the Contractor's expense.
- .3 REPAIRS OF DAMAGES TO FACILITIES: Specifications shall also contain provisions that damage to roads or other facilities on University property, resulting from hauling, storage of materials, or other activities in connection with the work, shall be repaired or replaced, at no expense to the University, by the Contractor causing the damage. Repairs or replacement shall be made to the satisfaction of the University Architect.
- .4 MAINTENANCE OF TRAFFIC FLOW:
  - .4.1 PLANNING FOR TEMPORARY CONTROL: The University Police Department must be notified at least two weeks in advance of any anticipated work affecting traffic flow. To assure maintenance of flow and to safeguard all parties involved in planning temporary routing, a field inspection should be made jointly by the A/E, The University, and Contractor personnel prior to performing any work that would interrupt normal traffic patterns. Rerouting of traffic shall be planned as to route and direction, in cooperation with the University Department of Public Safety and as approved by the University Architect.
  - .4.2 CONTRACTOR'S RESPONSIBILITIES: The contractor, whose work requires interruption of traffic, shall be required to post signs in all affected areas, in sufficient numbers and with appropriate messages, to warn motorists entering the construction zone and to alleviate conflicts and confusion among motorists or pedestrians at intersections, crossings, turns, and other obstructions to normal traffic flow. Temporary signs shall be as shown in the Ohio Manual of Uniform Traffic Control Devices for Streets and Highways, Ohio Department of Transportation. Temporary lanes shall be well marked, and obstructions, barriers, lane changes, or detours shall



be indicated by appropriate signage at each point of potential confusion, as well as at each change in direction of a temporary route. University Police Department shall be notified in advance of the anticipated time of return to normal traffic patterns. Upon completion of construction affecting streets or traffic flow, but before temporary control devices and lane markings are removed, the area shall be restored to receive traffic in the normal pattern. The Police Department shall be notified of the actual time of completion of restoration.

.4.3 PROVISIONS FOR SPECIAL DUTY POLICE OFFICERS: If it is evident that traffic will become hazardous or restricted in any manner, uniformed special duty police officers must be provided by and at the contractor's expense. These officers shall be employed by contacting the University Director of Public Safety at least two weeks before officers' services are required. The contractor shall also forward a copy of the request to the University Architect. Specifications should be written to alert contractors to the possibility that special duty police officers might be needed at times other than, or in addition to, the contractor's normal work hours.

.5 PARKING: Parking at regional campuses is subject to regulations established by University Authorities at the particular campus. At the Columbus campus, employees of contractors and subcontractors must secure parking permits from the CampusParc and must park cars in areas assigned to them. Parking on streets or in restricted areas is prohibited. At the beginning of the work, each contractor shall report to the CampusParc the approximate number of parking permits which will be required for all employees, including employees of subcontractors. Each contractor shall provide the University Architect with a copy of his letter of application for parking permits.

**OARDC:** Parking for employees of Contractors and subcontractors must be arranged with the University Project Manager, and must park in areas assigned to them. Parking on streets or in restricted areas is prohibited. Purchase of parking permit is not required.

#### **01 56 00. TEMPORARY BARRIERS AND ENCLOSURES**

.1 INGRESS AND EGRESS FOR BUILDINGS: During joint occupancy of buildings, entrances and exits for public use must be provided to meet code requirements. At least one ingress and egress and path of travel that is accessible to individuals with disabilities must be maintained to all user occupied portions of the building.

.2 SIDEWALK BARRICADES: Provide a detail for sidewalk barricades as required to discourage pedestrian traffic. The barricades are to be at least 42 inches high and of suitable width to completely obstruct passage beyond on the closed sidewalk. The barricade shall consist of: a rigid frame with a 2X6 wooden toe board affixed approximately one inch above the sidewalk across the entire width, cross bracing to hold the barricade in place, and orange safety fencing affixed to the frame. Specify/detail a sign stating "SIDEWALK CLOSED" affixed to the structure. Signage must meet all applicable ADA requirements.

## DIVISION 01 GENERAL REQUIREMENTS

---

- 01 56 16. NOISE AND DUST CONTROL: In occupied buildings the A/E shall indicate areas for which noise and dust control must be provided and shall specify methods of control. If details of installations are involved, specify these in the applicable sections of the technical specifications. The General Contractor or Lead Contractor shall install barriers indicated by the A/E and shall provide other dust control barriers as required by construction operations.
- 01 56 26. TEMPORARY FENCE: A 6 ft. high fence with gates shall be erected around the project site. Fence and location shall be subject to the approval of the University Architect. Show fence location on drawings.
- .1 Usually a heavy woven steel wire fence on steel posts is sufficient; however, where appearance is a consideration, a privacy type fence might be required, provided the budget permits such construction. Fence screening is required unless approved by the University Landscape Architect.
- .1.1 Fence screening is to be black, open mesh fabric made of polypropylene and providing a minimum of 80% shading. Fabric is to be installed on the inside of the fence.
- .2 Barbed wire used on any part of the fence is prohibited.
- .3 'No Trespassing' signs, which meet OSHA requirements, shall be specified.
- .4 WEED CONTROL: Specify that the General Contractor must cut the weeds inside the construction fence as often as necessary to maintain a neat appearance at the project site.
- 01 56 36. TEMPORARY SECURITY ENCLOSURES:
- .1 BUILDING SECURITY: During construction, one exterior door of any enclosed structure shall be provided with a lockset with an OSU security core. The General Contractor shall obtain security core from and return same to the University Architect.
- .2 FENCE GATES: Except during working hours, gates shall be kept locked by the General Contractor at all times.
- One gate shall be double locked with an OSU security padlock and the contractor's padlock in a manner that will allow access by unlocking either padlock. Other prime contractors may install their own padlocks if it is determined that they will require access to the area at time other than regular working hours. The OSU security padlock shall be obtained from, and returned to, the University Architect.
- 01 56 39. TREE AND PLANT PROTECTION: Refer to Division 31.

### **01 57 00. TEMPORARY CONTROLS:**

1. AIR POLLUTION NUISANCES PROHIBITED: The General Contractor or the Lead Contractor shall provide controls to prevent air pollution. In accordance with all federal and state codes, and the Ohio Administrative Code 3745-15-07 (Environmental Protection Agency, Chapter 3745-15, General Provisions on Air Pollution Control, paragraph-07, most current version) the emission or escape into the open air from any source or sources whatsoever, of smoke, ashes, dust, dirt, grime, acids, fumes, gases, vapors, odors, or any other substances or combinations of substances, in such manner or in such amounts as to endanger the health, safety or welfare of the public, or cause unreasonable injury or damage to property, is hereby found and declared to be a public nuisance. It shall be prohibited for any person to cause, permit or maintain any such public nuisance.
  
2. RESTRICTIONS OF EMISSIONS OF FUGITIVE DUST: The General Contractor or the Lead Contractor shall provide controls to prevent fugitive dust. In accordance with all federal and state codes, and the Ohio Administrative Code 3475-17-08 (Environmental Protection Agency, Chapter 3745-17, Particulate Matter Standards, paragraph-08, most current version), fugitive dust cannot be emitted from any source without taking reasonably available control measures to prevent it from becoming airborne. "Reasonably available control measures" means the control technology which enables a particular fugitive dust source to achieve the lowest particulate matter emission level possible and which is reasonably available considering technological feasibility and cost-effectiveness. These measures shall include but not be limited to:
  - 2.1 The use of water or other suitable dust suppressant chemicals for the control of fugitive dust from the demolition of existing buildings or structures, construction operations or the grading of roads or the clearing of land;
  - 2.2 The periodic application of asphalt, oil, water, or other suitable dust suppression chemicals on dirt or gravel roads or parking lots, and other surfaces which can cause emissions of fugitive dust;
  - 2.3 The covering, at all times, of open bodied vehicles, when transporting materials that are likely to become airborne;
  - 2.4 The paving of roadways and the maintaining of roadways in a clean condition; and
  - 2.5 The prompt removal, in such a manner as to minimize or prevent resuspension, of earth or other material from paved streets onto which earth or other material has been deposited by trucking or earth-moving equipment or erosion by water or other means.
  
- 01 57 13. TEMPORARY EROSION AND SEDIMENT CONTROL:
  - 1 OHIO EPA PERMIT for NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES): The A/E shall obtain this permit. Any construction activity that disturbs one or more acre of total land is required to obtain a National Pollution

Discharge Elimination System (NPDES) Construction General Permit (CGP) from the Ohio Environmental Protection Agency (Ohio EPA).

2. OHIO EPA NOTICE OF INTENT (NOI) AND STORM WATER POLLUTION PREVENTION PLAN (SWP3): If a NPDES Permit is required, the A/E shall prepare and submit a Notice of Intent (NOI) and Storm Water Pollution Prevention Plan (SWP3) to the Ohio EPA. The SWP3 is to be prepared in compliance with current provisions of the Ohio Water Pollution Control Act (Ohio Revised Code, Title LXI (sixty-one) Water Supply - Sanitation - Ditches, Chapter 6111 Water Pollution Control, most current version) and CGP. The NOI and SWP3 shall be reviewed and approved by the University Engineer and the Office of Environmental Health and Safety before submittal to the Ohio EPA. A copy of the NOI, SWP3 and letter from Ohio EPA granting permit coverage shall be maintained at the construction site for the duration of the project. Copies are to be made available to Ohio EPA upon request.
  - 2.1 The NOI and SWP3 shall be prepared and submitted to Ohio EPA in a timely manner, at least 21 days prior to beginning any site work. Allow adequate time for Ohio EPA approval.
3. COMPLIANCE WITH STORM WATER POLLUTION PREVENTION PLAN (SWP3): The General Contractor or Lead Contractor must maintain all erosion control practices in strict accordance with the SWP3 at all times throughout the site work. Representatives of the University, as designated by the University Architect, will make weekly inspections to assure compliance with the SWP3.
4. TEMPORARY EROSION CONTROL: The General Contractor or the Lead Contractor shall place temporary erosion and sediment control measures to minimize adverse impacts to storm water runoff. These control measures include the use of berms, dikes, dams, sediment basins, fiber mats, netting, gravel, mulches, grasses, catch basin/curb inlet protection, and slope drains, among other control devices or methods. These measures are to be coordinated with permanent erosion control features and plant materials. The selected control measures must also comply with appropriate provisions and plans in the City of Columbus, Division of Sewerage and Drainage Erosion and Sediment Control Regulation. Any plantings or mulches must also comply with all University Standards and be reviewed for prior approval by the University Landscape Architect.
5. SILT FENCE: The manufacturer's recommendation shall be followed with regard to shipping, handling, storage, installation, and protection from direct sunlight. The geotextile will be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, storage, or installation. Each roll shall be labeled or tagged to provide product identification.
  - 5.1 The post spacing shall be as recommended by the manufacturer. The spacing of the posts shall be adjusted such that some of the posts are located at the low points along the fence line. At joints, the overlap shall be nailed or similarly fastened to the nearest post with a lath.

6. STRAW BALES AND STRAW WATTLES: Straw bales and wattles shall be embedded and staked as shown in the SWP3. Adjacent bales or wattles shall be chinked to eliminate gaps between the bales or wattles. Bales shall be placed such that bindings are parallel to and not in contact with the ground.
7. TEMPORARY SILT DITCH: Construct a temporary ditch in relatively rolling areas where, in the judgment of the A/E, adjacent property may be damaged from sheet-type soil erosion. This special ditch is not intended to carry large volumes of water but to catch sediment from runoff. Construct silt checks within the ditch or at the outlet. Construct the special ditch according to the SWP3 at locations designated by the A/E.
8. TEMPORARY SEEDING AND PROTECTION: Before ordering, obtain the review and prior approval from the University Landscape Architect for any seed before use. Promptly perform the work of temporary seeding and protection to prevent visible erosion. Protect all seeded areas with mulch that precludes siltation. Perform temporary seeding and protection under the following conditions:
  - 8.1 When it is impractical to bring an area to final line, grade, and finish so that permanent seeding protection work can be performed without subsequent serious disturbance by additional grading.
  - 8.2 When soil erosion occurs, or it is considered to be a potential problem, on areas where construction operations are temporarily suspended.
  - 8.3 When an immediate cover would be desirable to minimize erosion, siltation, or pollution.
  - 8.4 On temporary roadways that are expected to remain in place for longer than 30 days and that are constructed of erodible materials.
9. TEMPORARY MULCH: Before ordering, obtain the review and prior approval from the University Landscape Architect for any mulch before use. When temporary seeding and protection would be required, but the time of exposure is 30 days or less, perform temporary mulching to prevent visible erosion. Place temporary mulch to an approximate 2-inch loose depth and apply tackifier.
10. CATCH BASIN/CURB INLET PROTECTION: Install and maintain catch basin or curb inlet protection on all existing inlets/basins receiving runoff from disturbed areas. All protection must be suitable for minimizing infiltration of silt into storm inlets as specified by the A/E and in the SWP3. The protection must be installed and maintained in accordance with the manufacturer's instructions.
11. TEMPORARY DRAINAGEWAYS: As erodible areas are exposed, construct temporary drainageways where needed to divert runoff from erosive soil areas to the silt traps or checks or silt ditches. Construct interceptor ditches or silt fences at the top of cut slopes when beginning excavation. Construct surface ditches, roadside ditches, and flumes to carry runoff from the site at the earliest possible time during the grading work.

11.1 When needed, use pipe as liners for these temporary drainageways. The A/E will approve the type and location of the drainageways as well as the need for a liner. Install the pipe liner according to the Plans and Standard Drawings. Use pipe of any substantial type or material for overflow pipe in the construction of temporary silt basins and for flumes. When fill slopes have been constructed to such a stage that protection of the face of the slope from runoff is necessary, construct a temporary earth mound ditch or silt fence at the outer edge of the shoulder along the top of the embankment as directed by the A/E. Construct the ditch to form an earth mound on the embankment side of the ditch and carry runoff from the roadway along the shoulder to the flumes and roadside ditches. Use temporary berm ditches at the top of fill slopes after completing the permanent seeding and protection work and until beginning the surface operations. Stabilize the ditch and mound by spraying with asphaltic material when deemed necessary.

12. CONSTRUCTION ENTRANCES. All ingress and egress points for construction vehicles (construction entrances) are to be constructed in accordance with the City of Columbus, Division of Sewerage and Drainage Erosion and Sediment Control Regulation.

**01 60 00. PRODUCT REQUIREMENTS**

**01 66 00. PRODUCT STORAGE AND HANDLING REQUIREMENTS**

.1 TRANSPORTATION AND HANDLING: Although scheduling of deliveries is the responsibility of the contractors, the A/E shall, by visual observation and by checking the contractor's estimates for partial payments, control deliveries to assure that storage spaces are not unduly encumbered with materials which cannot be installed in the work within a reasonable time. The General Conditions provide for payment for materials properly stored and insured at off-site locations.

.2 STORAGE AND PROTECTION: Specify that each contractor shall provide suitable weathertight storage sheds of sufficient size to hold materials required on the site at one time, for storage of materials which might be damaged by the weather. Outdoor storage of materials shall be confined to the areas within the construction fence.

Temporary structures shall be painted with at least one coat of paint; color shall be approved by the University Architect. No signs except small identification signs are permitted on sheds. Indoor storage shall be confined to unused spaces in the building. Corridors, stairs, and other public spaces shall not be used for storage. Special care must be exercised to protect electrical and HVAC equipment.

.3 STORAGE OF UNIVERSITY EQUIPMENT: Prior to completion of a building, large rooms at, or near, grade level with docking facility access shall be made available to the University for the secure storage of equipment. Details shall be arranged with the University Architect.

**01 70 00. EXECUTION AND CLOSEOUT REQUIREMENTS**

**01 71 23. FIELD ENGINEERING**

- .1 LAYOUT DATA: A licensed engineer or surveyor shall be employed to layout structure coordinates, site improvements, and utilities, to determine all lines and elevations, and to verify same from time to time as the work progresses.
- .2 GRADE LINES, LEVELS, AND BENCH MARKS shall be established and maintained by the General Contractor.
- .3 BUILDING LAYOUT DATA: The General Contractor shall provide and maintain well-built batter boards at corners of buildings. As work progresses, he shall establish bench marks at each level and shall establish exact locations of partitions on rough floors as guides to all trades.

**01 71 33. PROTECTION OF ADJACENT CONSTRUCTION**

- .1 ROOF PROTECTION: Specify that the Contractor shall provide protection for any roof area(s) that will be affected by the project. Protection shall consist of using ½-inch thick plywood with foam board attached. The composite board shall be laid with the foam towards the roof surface and shall be arranged to protect the roof from falling objects...i.e. hand tools, power hand tools and material. The protective covering shall be secured in a non-destructive fashion (i.e. weighted down) to avoid dislocation in inclement weather. This protection shall not relieve the Contractor from responsibility to repair any damage to the roof resulting from his work.

**01 77 00. CLOSEOUT PROCEDURES**

- .1 CLEANING: The A/E should review Article 26 of the General Conditions to determine whether or not this subject is adequately covered; some amplification might be required.

**01 78 00. CLOSEOUT SUBMITTALS:**

- 01 78 23. OPERATION AND MAINTENANCE DATA: Detailed requirements should be stipulated in the appropriate sections of the specifications. For items of General Construction, specify that information for care and maintenance be furnished for any item requiring more than ordinary custodial care. For mechanized equipment and electrical equipment, specify that operation manuals be provided in both hard copy and electronic Adobe Acrobat PDF format, and for special equipment stipulate that, in addition to operation manuals, the original equipment manufacturer provide demonstrations and operating instructions by factory trained employees to designated University personnel who will be operating the equipment. The following are merely suggestions for the kind of data which might be required. Also see 01 79 00.

.1 GENERAL CONSTRUCTION:

Item	Data Required
Simulated masonry	Surface treatment
Cut stone	Damp proofing treatment
Glue-laminated wood	Finishes
Wood shingles and shakes	Preservative treatment
Fluid applied roofing	Instructions for patching
Single-ply membrane roofing	Maintenance and repair instructions
Aluminum, bronze, and S.S.	Care of finishes
Doors and windows	
Electronic locking systems	Wiring diagrams and operating instructions
Special flooring	Finishes and maintenance data
Chalkboards	Cleaning instructions
Motor-operated chalkboards	Wiring diagrams and operating instructions
Pedestrian control devices	Wiring diagrams
Sun control devices	Wiring diagrams
Equipment	Wiring diagrams and any special instructions required
Special Construction	Systems diagrams and any special instructions required
Elevators and hoists	Operating and maintenance instructions

.2 PLUMBING:

Item	Data Required
Piping systems	Printed diagrams - valve tag directory
Pumps, controls, and special systems	Wiring diagrams, operating instructions, parts lists, testing procedures

.3 HEATING, VENTILATING, AND AIR CONDITIONING:

Item	Data Required
Control systems	Printed diagrams and operating instructions
Valves	Type-written valve tag directory
Pumps, controls, and special systems	Wiring diagrams, operating instructions, parts lists, testing procedures

.4 ELECTRIC:

Item	Data Required
Communications systems	Point-to-point wiring diagrams and instruction manuals
Motor control centers	Overload heater charts
Equipment	Operating instructions
Fire alarm systems	Point-to-point wiring diagrams



Product Data Sheets

- .5 OPERATION AND MAINTENANCE MANUALS: The A/E shall review the contractor's submittals of manuals for correctness and sufficiency of data and, after approving the contents and format, shall obtain the number of copies required, including three copies for resubmittal to the University Architect.
- .5.1 FORMAT FOR MANUALS: Manuals shall consist of manufacturers' typed or printed operation instructions and maintenance data, shop drawings and catalog cuts, and other data listed herein, in both hard copy and electronic Adobe Acrobat PDF format; all bound in 8-1/2" x 11" hard- back 3-ring binder. Material shall be assembled as follows:
- .5.1.1 INSIDE COVER: Project name and number, The Ohio State University, building name and address, date of submittal, name of contractor and name of manufacturer.
- .5.1.2 SECOND PAGE: Index
- .5.1.3 THIRD PAGE: Introduction to first section containing a complete written description of the equipment or system.
- .5.1.4 FIRST SECTION: Written description of system contents, where equipment is located in building, how each part functions individually and how system works as a whole, concluded with a list of items requiring service and the service needed or reference to the manufacturer's data in the 3-ring binder which describes proper service.
- .5.1.5 SECOND SECTION: A copy of each shop drawing with an index at the beginning of the section.
- .5.1.6 THIRD SECTION: A copy of manufacturer's operating instructions with an index at the beginning of the section.
- .5.1.7 FOURTH SECTION: A list of all equipment incorporated into the project, contractor's purchase order numbers, supplier's name and address.
- 01 78 36. AFFIDAVITS, AND GUARANTEES: In addition to the standard forms required by the contract documents, the following are required. When statements applying to these requirements are provided in these guides, the statements (or paragraphs similarly worded) shall be included in the specifications. The A/E can save a duplication of work at time of completion of construction if the specifications writer prepares a list of required affidavits, bonds, and guarantees as the specifications are prepared. Also see 01 33 13.
- .1 AFFIDAVITS
- |                        |  |
|------------------------|--|
| Carpeting materials    | - Installer attests that correct materials were installed        |
| Non-standard resilient | - Installer attests that correct floor Materials were installed. |

.2 EXTENDED GUARANTEES

- Roofing - 10 year maintenance guarantee
- Flashing and sheet metal work - 10 year maintenance guarantee
- Membrane waterproofing - 3 year maintenance guarantee
- Sealants - 5 year guarantee
- Silicone Sealants - 20 year warranty
- Metal windows - 2 year guarantee for windows/5 year guarantee for weatherstripping
- Wood laminated plastic faced doors - Lifetime guarantee
- Tinted glass and insulating glass - 10 year guarantee
- Chalkboards - 20 year guarantee
- Water chillers and air cooled condensers - 5 year guarantee

01 78 29. INSPECTIONS: Procedures shall be as outlined in the article entitled Construction and Closeout in the General Conditions

Inspection by the Authority Having Jurisdiction (AHJ) is required before obtaining new utility services including electric, gas, steam, chilled water or domestic cold water. For connection to campus systems follow procedures in the Utility Service Connection and Inspection Standards ([http://fod.osu.edu/sites/default/files/utility\\_service.pdf](http://fod.osu.edu/sites/default/files/utility_service.pdf)) and the Primary Electric Service Procedure ([http://fod.osu.edu/sites/default/files/primary\\_electrical\\_service.pdf](http://fod.osu.edu/sites/default/files/primary_electrical_service.pdf)). When applicable, contractors are to complete the requirements in the utility inspection checklists before requesting a substantial completion inspection.

01 78 39. PROJECT RECORD (AS BUILT) DOCUMENTS:

.1 CONTRACTORS' RESPONSIBILITIES: These are stipulated in the General Conditions.

.1.1 AS-BUILT DOCUMENTS shall be made available for review during weekly progress meetings. The in-progress as-built documents shall be neatly and accurately marked to reflect the actual construction of the project in relation to the work that had been completed to the date of the meeting. The Contractor shall provide the A/E with the final and complete as-built documents upon final completion of the work.

.1.2 OPERATION AND MAINTENANCE MANUALS shall be made available for review during weekly progress meetings. The manuals shall be submitted as equipment and systems are installed and prior to Demonstration and

Training. Submittals shall include both hard copy and electronic Adobe Acrobat PDF format.

.2 ARCHITECT/ENGINEER'S RESPONSIBILITIES: After final acceptance of the project, the A/E shall revise the construction documents in electronic format to accurately record the project's "as-built" condition and note on each drawing file "RECORD DRAWINGS". Identify the addenda, bulletin, change order, alternate, etc. for each item. Submit the revised electronic files to the PARE Archive Data Manager for review. Make any additional modifications and submit the electronic files. Also provide in the most recent version of Adobe Acrobat or Microsoft Word in PDF formats a copy of the specifications and general conditions modified by the addition of each accepted addenda, alternate, each accepted bulletin and change order and identification of the brands of materials which were accepted when choices were available to the contractors along with supporting electronic files. The University Architect will distribute this material to Programmed Maintenance (2 copies), the building project (1 copy), and all electronic files to the Archive Data Manager. Identify the AutoCAD .dwg and .pdf format and other documents with the label "RECORD DOCUMENTS".

.2.1 ELECTRONIC FILE SUBMITTALS shall be presented in a logical manner with appropriate directory and subdirectory structures, shall follow all applicable guidelines as referenced in the Electronic Drawing Naming Requirements ([http://www.fod.osu.edu/sites/default/files/Electronic\\_Drawing\\_Naming\\_Reg.doc](http://www.fod.osu.edu/sites/default/files/Electronic_Drawing_Naming_Reg.doc)) and the Record Documents Submittal Guidelines ([http://www.fod.osu.edu/sites/default/files/Record\\_Documents\\_Guidelines.doc](http://www.fod.osu.edu/sites/default/files/Record_Documents_Guidelines.doc)) found on the Project Delivery Website (<http://www.fod.osu.edu/project-delivery>), and shall: reflect the final "As Built" conditions and noted as "RECORD DRAWINGS" on each drawing file; be delivered on Windows-format CD-ROM(s); and adhere to the following guidelines:

- Drawings:
  - Shall be delivered in AutoCAD and Adobe Acrobat PDF format;
  - Shall have externally referenced drawing files permanently bound to the final drawing file by the consultant prior to delivery;
  - Shall have all reference files bound (font files, menus, shape files, etc.) delivered along with the final submittal. If copyrights prohibit this, such reference files shall not be used on the project;
  - Shall strictly adhere to the current published AIA guidelines for layering standards.
- Technical Specifications:
  - Shall be delivered in the most recent version of Adobe Acrobat or Microsoft Word in PDF formats.
- Operating and Maintenance Manuals:

DIVISION 01 GENERAL REQUIREMENTS

---

- Shall be delivered in the most recent version of Adobe Acrobat or Microsoft Word in PDF formats.

- .2.2 DATA NOT IN ELECTRONIC FORMAT, but part of the final document submittal, (i.e. details that are 'sticky-backed' onto the plotted sheets), shall be noted in the electronic files completely, including a description of the drawing(s) and scanned in Adobe Acrobat PDF format.
- .2.3 Building Information Modeling (BIM): The Architect/Engineer, or Contractor shall meet, for projects four million dollars or greater, the BIM Project Delivery Standards (BIM PDS).

.3 SUBMITTAL SHALL CONSIST OF: A database file which compares the Program of Requirements Assignable Square Footage to that of the Schematic Design Document, the Design Development Document, the Construction Document, and the As-Built Document. This submittal must be in the following format:

TITLE BLOCK

Project Name:  
Project Number:  
Project total gross square footage (GSF):

Column #	Column Header
1	PoR Item Number
2	PoR Item Name
3	PoR ASF
4	Schematic Design ASF
5	PoR/Schematic Design ASF Difference
6	Design Development Room Number
7	Design Development ASF
8	PoR/Design Development ASF Difference
9	Construction Document Room Number

Column #	Column Header
10	Construction Document ASF
11	PoR/Construction Document ASF Difference
12	As-Built Room Number
13	As-Built ASF
14	PoR/As-Built ASF Difference

This file should also contain a subtotal by Program Item Number Group (e.g. all spaces under Program Item Number 1.0 would be subtotaled). A Project total ASF should also be included (totals all Program Item # Group ASFs).

.4 REQUEST FOR A/E'S FINAL PAYMENT: After the corrected electronic drawings have been reviewed and accepted by the University Architect and the Facilities Operations and Development's Archive Data Manager. Final payment of fees will not be approved until acceptable documents are received.

**01 79 00. DEMONSTRATION AND TRAINING**

- .1 Specify that training is to be done by the original equipment manufacturer. (See Appendix T for a sample specification for system training). Training by the contractor or sales personnel is prohibited.
- .2 Training shall be identified separate from “start-up and check-out” in the specifications.
- .3 Specify that training shall be scheduled through the University Project Manager.
- .4 Training shall include all materials; i.e. OEM manuals, books, plans, and specifications necessary for equipment troubleshooting and maintenance by in-house maintenance department, as appropriate.
- .5 Specify that the OEM shall provide labor for miscellaneous support during the warranty term.

END OF DIVISION 01 – GENERAL REQUIREMENTS

## **DIVISION 02 – EXISTING CONDITIONS**

2010 Edition, Published January 1, 2010; Document Revision Date: February 7, 2017

### **02 00 00. EXISTING CONDITIONS**

#### **02 30 00. SUBSURFACE INVESTIGATION**

- .1 Architect/Engineer RESPONSIBILITIES: The Architect/Engineer shall direct and provide site or subsurface investigation judged necessary in accordance with the Architect/Engineer's Agreement for professional services. This will include contacting Environmental Health and Safety within Facilities Operations and Development for any university records of site hazards, investigative work and surveyor reports, testing laboratories (including test borings), soil analysis (including load bearing capabilities) and related site analysis. Submit two copies of any site investigative reports to the University Architect. Also see (33 40 00).
- .2 INFORMATION TO BE INCLUDED IN CONTRACT DOCUMENTS: Show all boring locations, cross sections and soil conditions. Also show all: existing conduits, drains, utility lines, sewers, tunnels, cables, trees, paving, walks, foundations and other objects or obstructions, whether in use or abandoned. State that information is for contractor's use and that in no way shall the University be held responsible for accuracy of the information.
- .3 PROTECTION OF EXISTING LANDSCAPING: Protect all trees, walks, and planted areas during subsurface investigations. All existing site elements shall be left in their original condition. See section (32 10 00) for minimum design standards for paved areas. Coordinate all work with Facilities Operations and Development.
- .4 PREPARATION OF PLANS FOR BORINGS: In the preparation of plans for boring locations, the Architect/Engineer shall study plans of existing underground utilities and shall locate borings to avoid these utilities. Maps showing underground installations are available for review upon request from Facilities Operations and Development.

#### **02 40 00. DEMOLITION AND STRUCTURE MOVING**

- .1 STRUCTURE DEMOLITION: All foundations and basement slabs of structures shall be fully removed. A variance may be requested for special conditions.

#### **02 44 00. EQUIPMENT MOVING**

- .1 RELOCATED EQUIPMENT: Special concern shall be taken with equipment relocated from existing installations for reinstallation. Establish schedule for removal and reinstallation through the University Project Manager. Identify a single contractor to be solely responsible for removal, disposal, re-installation and follow-up. Relocation of existing equipment shall include:
  - .1.1 Disconnecting and moving to new location.
  - .1.2 Restoration and capping of utilities at the old location.
  - .1.3 Specify that the contractor record existing piping arrangements to facilitate reinstallation..
  - .1.4 The contractor shall be required to replace unsalvageable piping, ductwork, and wiring, and furnish any new piping, ductwork, and wiring as required to complete reinstallation, without additional cost to the University.

## DIVISION 02 – EXISTING CONDITIONS

---

- .1.5 The contractor is to provide a separate container for the recycling of paper, cardboard, and wood products.

### 02 82 00. HAZARDOUS MATERIALS AND ASBESTOS REMEDIATION

- .1 HAZARDOUS MATERIALS AND ASBESTOS REMEDIATION: The general industry and construction asbestos standards (29 CFR 1910.1001 and 1926.1101) and National Emission Standards for Hazardous Air Pollutants (NEHSAP) hazardous materials and asbestos standards establish specific requirements for building owners. Should hazardous materials be disturbed during any renovation repair or demolition, the hazardous materials must be properly removed and disposed of at an approved landfill. **Building owners are therefore required to know how their hazardous building materials will be impacted by the renovation repair, or demolition project.** Examples of hazardous materials in addition to asbestos include, but are not limited to: polychlorinated biphenyls, mercury containing components, tritium, and lead sheeting. In all cases, hazardous material abatement activities must be performed by **Ohio Department of Health (ODH) licensed individuals. Building owners are also required to assure that applicable Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and additional ODH regulations are complied with during the hazardous materials abatement activities.**
- .1.1 The purpose of this building design standard is to provide the Architect/Engineer (A/E) with guidance in developing specifications to ensure that any asbestos or other hazardous materials testing documentation and abatement work is performed by a qualified and licensed Environmental Consultant (EC) and abatement contractor in compliance with all applicable regulations. **The University's Office of Environmental Health and Safety (EHS) is responsible for managing the University's asbestos and for compliance with federal and state regulations. EHS maintains an historical listing of sampling for asbestos in all University buildings throughout Ohio and must be contacted for direction with asbestos issues.**
- a. **The University requires the Environmental Consultants (EC)** to have a minimum of two (2) years experience preparing abatement, drawings, designs and technical specifications and shall be licensed by the Ohio Department of Health as an "Asbestos Hazard Abatement Project Designer".
  - b. **The University requires the (EC)** performing hazard materials assessments to have a minimum of two (2) years of experience performing asbestos surveys or asbestos material sampling. The (EC) performing asbestos confirmation surveys, including but not limited to obtaining bulk samples and quantification of ACMs shall be licensed by the Ohio Department of Health as an "Asbestos Hazard Evaluation Specialist". The (EC) shall provide an electronic and hard copy of all Hazard Materials Assessment reports to EHS.
  - c. **The University requires the (EC)** shall act as the University's compliance agent and be responsible for confirmation of asbestos-containing materials (ACMs), preparation of asbestos abatement technical specifications and drawings. (EC) shall assist in the Bidding Phase, review of submittals and RFI's, provide periodic inspections or full-time oversight, final visual inspections and clearance air testing services and provide all close-out documents required for the abatement within renovation or demolition project areas. The (EC) shall also clarify the working relationship and expectations of the abatement contractor, (EHS), and all other participants.
  - d. **The University requires the (EC)** performing monitoring, periodic observations or inspections, final visual inspections and clearance air testing

## DIVISION 02 – EXISTING CONDITIONS

---

to have a minimum of two (2) years experience performing these tasks. The (EC) shall be licensed by the Ohio Department of Health as an “Asbestos Hazard Evaluation Specialist” and “Asbestos Hazard Abatement Specialist”. The (EC) shall have experience performing work with State Agencies; University settings and or City Municipalities and shall provide substantial documentation on at least three projects of similar scope and extent.

- e. The University requires (EC) of the following when performing hazardous materials inspections or assessments:
  - (1) Daily Phase Contrast Microscopy (PCM) air sampling to be conducted during bulk sampling of building materials. All PCM air data results are to be included with inspection or assessment reports.
  - (2) Include the date of the inspection, address of the building, name, address and phone number of the client on the report.
  - (3) Include the name, signature, and asbestos hazard evaluation specialist number of the person writing the report.
  - (4) Include a blueprint, diagram, or written description detailing the exact location where each sample was collected, the date of collection, and the homogeneous areas and footages where friable and non-friable suspected asbestos is assumed to be.
  - (5) Include a blueprint, diagram, or written description that identifies the location of hazardous materials, type of materials, and approximate square or linear footages where materials were confirmed to be asbestos containing or hazardous.
  - (6) A description of the manner used to determine sampling locations, and the name, signature, and asbestos hazard evaluation specialist number of each person collecting the samples
  - (7) A copy of the bulk sample analysis report, the name and address of any laboratory that analyzed the bulk samples, the date of analyses, and the name and signature of the person performing the analysis.
  - (8) Document and consult with Environmental Health and Safety (EHS) when testing results find trace amounts of asbestos-containing materials (less than 1% asbestos). The University requires that all building materials containing trace amounts of asbestos as confirmed by the analysis of bulk samples analyzed by Polarized Light Microscopy (PLM) or Point Count Method and impacted by the scope of the renovation or demolition work be removed and legally disposed of in accordance with all applicable requirements.
  
- f. The University requires (EC) of the following when performing on-site monitoring:
  - (1) Ensure that the environmental abatement contractor is performing all work in compliance with all applicable federal, state, and local regulations; including, but not limited to: EPA, OSHA, and ODH.
  - (2) Primary calibration source should be calibrated on an annual basis.



## DIVISION 02 – EXISTING CONDITIONS

---

- (3) Secondary calibration sources shall be calibrated quarterly.
  - (4) Environmental, ambient, area, and clearance samples shall be analyzed on a daily basis. The microscopist needs to participate in the American Industrial Hygiene Association (AIHA) Proficiency Analytical Program (PAT) program for fiber counting and analyze air samples via the National Institute of Occupational Safety and Health (NIOSH) 7400 method. In addition, the microscopist shall have completed the NIOSH 582 Equivalent course training.
  - (5) Ensure that all air samples are collected within the breathing zone at an approximate 45 degree angle. All pumps shall be connected to electric via a Ground Fault Circuit Interrupter (GFCI), which should be directly connected to the electric source.
  - (6) Provide daily access to a daily logs / field notes, air data, and inspection forms.
  - (7) Contact OSU EHS immediately should any regulatory agencies visit the project site.
- g. The University requires (EC) of the following when preparing closeout documentation:
- (1) Review all environmental contractor closeout documents, which at minimum should include the following: daily logs, sign-in sheets, contractor license, BWC certificate, liability insurance certificate, supervisor and worker submittals (certificate, license, medical, fit test) materials safety and data sheets, notifications (EPA, ODH, OSU EHS), waste manifest and signed landfill disposal receipt.
  - (2) Include the following documents within the closeout documents: a field report summarizing a description of the project and the hazardous materials abated copy of the specifications / drawings, daily logs, inspection forms, and air data.
  - (3) Combine contractor documents with environmental consultant documents and submit copies electronically. A hard copy of the original signed landfill receipt must be submitted to the university. Submit closeout documents to OSU within a timely manner of receiving signed landfill receipt.
- .2 REGULATORY CONFORMANCE: When hazardous material work is involved, specifications must require conformance to all pertinent provisions of Federal, State of Ohio, and Local laws, codes, rules and regulations for removal or control of asbestos. These provisions include:
- .2.1 U.S. EPA National Emission Standards for Hazardous Air Pollutants (NESHAP); Asbestos: 40CFR (Code of Federal Regulations), Part 61, Subparts A and M).
  - .2.2 U.S. Department of Labor Occupational Safety and Health Administration (OSHA) Asbestos standards: 40 CFR Part 29, Section 1910.10001 (General Industry) and 1926.1101 (Construction).
  - .2.3 U.S. EPA, "Guidance for Controlling Asbestos-Containing Materials in Buildings" (the "Purple Book").

## **DIVISION 02 – EXISTING CONDITIONS**

---

- .2.4 ANSI Practices for Respiratory Protection (ANSI Z88-2-1969) and OSHA Personal Protection Equipment Standard: 29 CFR 1910 Subpart 1.
  - .2.5 EPA notification for the OSU Columbus and Newark Campuses goes to the Central District Office of Ohio EPA; for Lima, Mansfield, Marion and Stone Lab campuses goes to the North West District Office of Ohio EPA and for OARDC goes to the North East District Office of Ohio EPA. With exception of the abatement work performed by Facilities Operations and Development, the University holds the contractors responsible for making all required notifications.
  - .2.6 U.S. EPA Comprehensive Environment Response, Compensation and Liability Act (CERCLA): 40 CFR 763.117 and .302.
  - .2.7 U.S. Department of Transportation: 49 CFR 171 and 172.
  - .2.8 Ohio EPA Asbestos Emission Control Rules: Ohio Administrative Code 3745-20.
  - .2.9 Ohio Department of Health (ODH) Asbestos Hazard Abatement Rules: Ohio Administrative Code 3701-34; and Ohio Revised Code Chapter 3710.
- .3 **QUALIFICATIONS FOR ASBESTOS ABATEMENT CONTRACTORS:** Prior to bidding, contractors and/or subcontractors involved in hazardous materials abatement work shall be required to meet the following minimum requirements: These requirements and the documentation specified in .3.3 will be reviewed by University staff in determining whether the Abatement Contractor is acceptable to work on University projects:
- .3.1 **Required Certifications**
    - .3.1.1 The Asbestos Abatement Contractor shall be certified by the ODH to perform asbestos abatement activities as required by Chapter 3701-34 of the Ohio Administrative Code.
    - .3.1.2 The Asbestos Abatement Contractor's Supervisor shall be certified by ODH as an Asbestos Hazard Abatement Specialist.
    - .3.1.3 Each of the Asbestos Abatement Contractor's employees, including full-time employees, temporary employees and contract labor, shall be certified by ODH as either an Asbestos Hazard Abatement Worker or as an Asbestos Hazard Abatement Specialist.
  - .3.2 **Required Experience**
    - .3.2.1 The Asbestos Abatement Contractor shall have a minimum of two (2) years experience in asbestos and hazardous materials abatement projects.
    - .3.2.2 The Asbestos Abatement Contractor shall have experience performing work in similar settings and shall provide substantial documentation summarizing these projects including the project location, duration, scope of work, monitoring, documents, client contact information and any additional information requested.
    - .3.2.3 The Asbestos Abatement Contractor shall have experience on at least three projects of a similar scope and extent.

## DIVISION 02 – EXISTING CONDITIONS

---

- .3.3 The Asbestos Abatement Contractor shall report any Public Health Emergency Violations issued by the ODH within the past two (2) years and not have any previous unresolved or pending Public Health Emergencies.
- .3.4 The Asbestos Abatement Contractor shall provide the following documents prior to the post-bid review meeting:
  - .3.4.1 References from previous projects:
    - a. Previous experience on at least three projects of a similar nature (such as pipe, ceiling, boiler insulation, etc.) and extent shall be documented.
    - b. Three to five references specific to the Contractor's proposed Supervisor for this project.
    - c. Each reference to include contact information and phone number for the Owner, Architect, Construction Manager, and Subcontractors.
    - d. Provide documentation of the project location, duration, scope of work, and client contact information.
    - e. Verification of years experience in asbestos abatement projects, both for the contractor and for the supervisor.
    - f. Photocopies of ODH licenses for each of the Contractor's employees to be used on this project.
    - g. Positive identification via photocopies of valid driver's license or by other means as specifically approved by the Environmental Consultant for each of the Contractor's employees to be used on this project.
  - .3.4.2 Resume of proposed Supervisor for the project.
  - .3.4.3 Summary of current abatement projects. Include contract value and completion dates.
  - .3.4.4 Summary and background of any EPA violations over the past 7 years; as well as a statement as to how the violations were resolved (if applicable).
  - .3.4.5 Summary and background of any ODH violations over the past 7 years; as well as a statement as to how the violations were resolved (if applicable).
  - .3.4.6 Summary and background of any OSHA violations over the past 7 years; as well as a statement as to how the violations were resolved (if applicable).
  - .3.4.7 Copy of license to conduct asbestos abatement activities.
- .4 GENERAL REQUIREMENTS
  - .4.1 The contractor of a successfully bid project shall submit an asbestos abatement plan and have it reviewed by EHS and approved **by the EC** prior to commencing the work. The asbestos abatement plan shall have detailed written operating procedures describing control and removal techniques to be used as required by Chapter 3701-34-11 of the Ohio Administrative Code.
  - 4.2 The contractor shall electronically submit a notification form to EHS a minimum of five (5) business days prior to starting the abatement on-site.

## DIVISION 02 – EXISTING CONDITIONS

---

- 4.3 The contractor shall notify EHS immediately should any regulatory agencies visit the project site.
- 4.4 The contractor shall ensure that a competent person remain outside of the work area during abatement activities. A minimum of one person meeting the qualifications described above for supervisor shall be present on site at all times during any abatement work or activities and be able to communicate effectively with the workers and all governing authorities.

Except in the case of an emergency, anyone entering an asbestos abatement work area, which is an OSHA-defined “regulated area,” shall have received a minimum of 2-hour asbestos awareness training consistent with the EPA requirements.

- 4.5 The contractor shall ensure that a 3-stage decontamination (clean room, shower, dirty room) chamber system is established directly adjacent to all full containments or when abating more than 25 linear or more than 10 square feet of friable regulated asbestos containing material. Three-stage decontamination chamber shall be equipped with air lock chambers, working hot and cold water, and a 5 micron filter system.
- 4.6 The contractor shall ensure that the OSHA required asbestos danger signage in the English language is posted at all entrances to the work area. Areas of abatement work must be clearly demarcated. In all structures, whether partly occupied or not during asbestos removal, maintain clearly identified routes of egress
- 4.7 The contractor shall ensure that GFCIs are directly connected to all electrical sources in use outside of the work areas.
- 4.8 The contractor shall ensure that street clothes are not worn beneath protective clothing when abating more than 25 linear feet or more than 10 square feet of friable regulated asbestos containing material. In the event that street clothes are worn beneath protective clothing, the contractor shall render these clothes as asbestos-containing and manage accordingly.
- 4.9 The contractor shall ventilate all air-filtration devices (AFD) to the exterior of the building. The preferred procedure is to direct the exhaust out a window. If this is not feasible due to the project conditions, submit alternative procedure to University Project Manager for approval.

Exhaust from AFDs shall not be directed into the airspace above a dropped ceiling or into existing laboratory hood ventilation.

- 4.10 The contractor shall collect daily OSHA personal PCM air samples and post analytical results on a daily basis. The laboratory needs to participate in the AIHA PAT program for fiber counting and analyze air samples via the NIOSH 7400 method. In addition, the microscopist shall have completed the NIOSH 582 Equivalent course training. Records shall be maintained to show air quality levels prior to, during and after asbestos abatement work on projects. These records shall show sample results of environmental and personal air data results.
- 4.11 The contractor shall ensure that all critical barriers are sealed with 6-mil polyethylene within the work area(s), all HVAC and electrical systems are de-energized within the work area, and all HVAC vents are sealed with two layers of 6-mil polyethylene.

## **DIVISION 02 – EXISTING CONDITIONS**

---

- 4.12 The contractor shall ensure that all full containments contain a minimum negative pressure of 0.02 inches of water column.
- 4.13 The contractor shall ensure that all asbestos containing materials are adequately wetted with amended water during removal and disposal.
- 4.14 The contractor shall ensure that all asbestos waste disposal bags are labeling with the OSHA asbestos danger and generator labels.
- 4.15 The Asbestos Hazard Abatement Specialist (Supervisor) shall conduct a final visual inspection and ensure that all visible suspect and confirmed asbestos debris has been successfully removed and disposed of properly upon completion of the project.
- 4.16 The contractor shall dispose of all ACM waste in an Ohio approved landfill and obtain a copy of the signed disposal receipt as required by the EPA.
- 4.17 The contractor shall include the following as part of the closeout documents: daily logs, sign-in sheets, contractor license, BWC certificate, liability insurance certificate, supervisor and worker submittals (certificate, license, medical, fit test) materials safety and data sheets, notifications (EPA, ODH, OSU EHS), waste manifest and signed landfill disposal receipt.

### **.5 ABATEMENT DESIGN SPECIFICATIONS**

- .5.1 The EC should download and review the Abatement Design Checklist for use in preparing the Abatement Technical Specifications for each project.
  - 5.1.1 The Abatement Design Checklist can be downloaded from the EHS website. Go to <http://www.ehs.osu.edu> and click on the “Environmental Affairs” tab; the “Hazardous Materials Management” page; DOCUMENTS (right side of the page/first listing).

END OF DIVISION 02 – EXISTING CONDITIONS

## **DIVISION 03 - CONCRETE**

2006 Edition, Published January 1, 2006; Division Revision Date: August 1, 2012

### **03 00 00. CONCRETE**

- 03 00 10. Minimum Standards to comply to: City of Columbus Construction and Material Specifications Item 511 for Concrete for Structures and Item 450 for Rigid Pavements.
- 03 00 20. STRUCTURAL DESIGN OF SLABS: Consideration shall be given in the design of floor and roof slabs to provide exposed construction which can be used as finished ceilings insofar as practicable. Such construction, however, shall be planned only if requirements for limits in heat losses and for noise control can be met.
- 03 00 30. DESIGN OF CONCRETE FOOTINGS: Bottoms of footings for exterior foundations should be at least 3'-0" below finish grade.
- 03 00 40. Concrete mix designs shall be included in the shop drawings submission and submitted a minimum of 30 days prior to first concrete placement.
- 03 00 50. Unprocessed bank run materials shall not be used in any concrete mix.

### **03 30 00. CAST-IN-PLACE CONCRETE**

- .1 ON-SITE SUPERVISION: The Architect/Engineer (A/E) or his approved representative shall observe the placing of all concrete and shall report non-compliance with specifications and drawings to the University Architect/Engineer.
- .2 TESTS: A minimum of 4 test cylinders prepared in accordance with ASTM C495 shall be taken during each day's placement. Tests shall be made by a testing laboratory employed and approved by the A/E. The cost of these tests will be reimbursed by the University. Written reports of the tests shall be sent directly to the A/E, with a copy to the University Architect/Engineer. Laboratory shall make tests for wet density, dry density, and compressive strength of each specimen.
- .3 MISCELLANEOUS REQUIREMENTS:
  - .3.1 INTERIOR BUILDING CONCRETE: Specify a mix which will give compressive strength of not less than 3,500 psi in 28 days; except that 1,500 psi concrete may be specified for filling over-excavations for footings.
  - .3.2 EXTERIOR CONCRETE: An approved air-entraining admixture shall be used for all concrete exposed to weather. Minimum strength shall be 4000 psi. Aggregate for exterior concrete exposed to view shall be washed crushed limestone only.
  - .3.3 INTEGRAL FINISH shall be specified for all floors. No separate topping.
  - .3.4 HARDENER TREATMENT: All finished floors that will be left exposed shall receive hardener treatment. Verify that the hardener used is compatible with the finish material curing requirements as listed by the manufacturer.
  - .3.5 PROTECTION FOR NOSINGS on concrete steps shall be provided by rounded cast nosing with non-slip surface.

## DIVISION 03 – CONCRETE

---

- .3.6 NON-SLIP SURFACING: Ramps, treads, and platform of stairs shall have non-slip surface when not covered with finish flooring materials.
- .3.7 Vapor Barrier is required for Slabs on Grade
- .3.8 Post-tensioned concrete is prohibited in occupied structures.
- .3.9 The minimum concrete protection for reinforcement as defined by ACI 318 shall be increased by 25% to ensure the minimum cover is maintained.
- .3.10 CURING COMPOUND CAPABILITY: Curing compound manufacturer is to provide certification that their product is compatible with the resilient flooring or carpet adhesive scheduled for the space.
- .3.11 Concrete is to be placed and consolidated at air temperatures between 40 and 85 degrees Fahrenheit for the first 72 hour period after placement. If these temperatures are unable to be maintained, ACI 305 and ACI 306 must be followed
- .3.12 If the main structural element of a building is to be concrete, the University requires construction to be a Cast-in-Place concrete structure. The use of Precast, Prestressed, Post Tensioned concrete construction methods for structures require written approval from the University Engineer.

### 03 33 00. ARCHITECTURAL CONCRETE:

- .1 SPECIFICATIONS shall meet current standard specification for architectural concrete as published by the American Concrete Institute.
  - .2 A SAMPLE PANEL 4 feet by 8 feet in size shall be erected at the site when cast-in-place architectural concrete is to be used. Panel shall be protected from construction operations, but shall be left exposed to the elements. Apply curing compound if specified for the final product – see Division 03 37 00. Panel shall be left in place until the University Architect has approved all architectural concrete.
- 03 34 00 ROOF FILL: Lightweight concrete for roof fill shall be made with expanded shale aggregate. For consideration of other materials, the A/E shall submit his recommendation with complete back-up documentation to the University Architect/Engineer.
- 03 34 10. INSULATING CONCRETE ROOF DECKS: Concrete shall have the following characteristics:
- Wet Density: 40-60 lbs. per cu. ft.
  - Dry Density: 20-30 lbs. per cu. ft.
  - Compressive Strength: 125-225 psi
- 03 37 00. CURING COMPOUNDS: Require a manufacturer's certification that the compounds used for architectural concrete are non-yellowing and non-staining. Compound must be applied to sample panels.

## **DIVISION 03 – CONCRETE**

---

- 03 40 00. PRECAST CONCRETE:** if approval was granted by the University Engineer to use precast concrete the following design standards are to be followed.
- 03 41 00 PRECAST STRUCTURAL CONCRETE: Base design and specifications on recommendations of the American Concrete Institute, ASTM tests and the Precast/Prestressed Concrete Institute (PCI).
- 03 41 10. PRECAST CONCRETE PANELS: Base design and specifications on recommendations of the American Concrete Institute, ASTM tests and the Precast/Prestressed Concrete Institute (PCI).
- 03 45 00. ARCHITECTURAL PRECAST CONCRETE: Follow the design and specification recommendations of the Precast/Prestressed Concrete Institute (PCI) for architectural precast concrete.

---

END OF DIVISION 03 CONCRETE



**DIVISION 04 - MASONRY**

2006 Edition, Published January 1, 2006; Division Revision Date: August 1, 2012

**04 00 00. MASONRY**

**04 00 03. GENERAL PROVISIONS**

- .1 SPLIT COURSING: Only full coursing will be permitted at the head of any type of opening.
- .2 OVERHUNG MASONRY: Construction where the masonry units are suspended using mechanical devices, or where the units extend beyond lower courses and mechanical support devices are required, are not to be used. Buildings being renovated/restored, which have such overhung structures, shall be examined for safety and a report of condition provided.
- .3 USE OF INK MARKING PENS ON SURFACES of any kind of material is prohibited. Experience has shown that such marks bleed through paint and other finishes.
- .4 ACID FOR MASONRY CLEANING: The cleaning solution must be included in applicable sections of the Specifications. Type of solution shall be approved by the University Architect's Office.
- .5 BRICK SURFACE TREATMENT: Treating of brick surface with stain or other surface treatment or simulation to obtain a color blend is prohibited.

**04 01 20. MASONRY RESTORATION AND CLEANING**

- .1 EXPERIENCE CLAUSE: A 10-year experience record of the subcontractor is required. Include the following paragraph in the specifications.

CERTIFICATION OF EXPERIENCE: Work shall be performed by experienced and skilled mechanics. The General Contractor shall furnish evidence that the subcontractor for restoration work has been engaged in the business of masonry restoration for a period of at least 10 consecutive years prior to the date of these specifications. Evidence or certification of experience shall be in letter form which, in addition to statement of experience, shall contain a list of at least five projects of comparable size and complexity which have been satisfactorily completed, a statement that proper equipment is available for use, and a statement that the work will be under the direct supervision of skilled mechanics only.

**04 05 13. MORTAR**

- .1 MORTAR FOR LAYING MASONRY: May be ready-mixed or job mixed. Specify by types listed in ASTM C-270. Do not specify mortar, which may corrode steel reinforcement or structure.
- .2 POINTING MORTAR: Pointing mortar for clay facing tile masonry shall be made with white silica sand and white portland cement. Also see 04 40 20.1.3.

**04 05 19. MASONRY ANCHORAGE AND REINFORCING**

- .1 WALL TIES for masonry veneer or facing to metal stud wall back-up may be stainless steel bolts and nuts and stainless steel washers. Sheet metal screws and similar attachments are not acceptable. Verify the need for seismic clips and anchoring for masonry veneer.

## **DIVISION 04 - MASONRY**

---

- .2 JOINT REINFORCEMENT: Wire mesh type is prohibited. Trussed type is preferred over ladder type. Provide ladder type joint reinforcement at vertically reinforced masonry walls and truss type in non-reinforced walls. Also see 04 21 00.1.

### **04 05 23. MASONRY ACCESSORIES**

- .1 WEEP HOLES: Stamped aluminum louvered vents of size to fit head joints in brickwork are preferred over treated sash cord or rope. If cord or rope is specified, they shall be cotton cord or rope, and the material shall be left in place and cut off flush with the joint. Artificial fiber ropes, such as nylon or polypropylene, are prohibited.

Mortar Net or a comparable mortar collection product shall be added at the base of the veneer and single wythe concrete masonry walls to prevent clogged weep holes.

- .2 MISCELLANEOUS: Also see 04 40 20.1.4.
- .3 PLUG ANCHORAGE by use of wood or plastic is prohibited.

### **04 20 00. UNIT MASONRY**

- 04 21 13. BRICK MASONRY: Color and blend of face brick shall generally be specified to match brickwork in a specific adjacent building. Consult the University Architect regarding this requirement.

- .1 EFFLORESCENCE TEST FOR FACE BRICK: Submit to the University Architect manufacturer's certification that bricks show no efflorescence when tested in accordance with ASTM Method C67.

- .2 SAMPLE PANEL: Include the following paragraph in the specifications:

SAMPLE PANEL: Before starting work, build one sample panel for inspection and approval. Build panel on a firm foundation, in location indicated by the A/E. Panel shall be F-shaped, with long side a minimum of 5 feet 4 inches long by 3 feet 4 inches high, with one corner return at least 2 feet long and with one intersecting 6 inch thick concrete block wall 2 feet long. Construct long side and return of 8 inch concrete block and face brick. Panel shall show color range and texture of masonry units, bond, mortar joints, and workmanship. Completed masonry work in the building shall be equal to that shown in the approved panel. Do not remove panel until masonry work is completed or until removal is authorized.

- .3 MATCHING MORTAR: If adjacent mortar is to be matched, samples of the original mortar are to be taken from the joints and analyzed for aggregate content, binder material, overall coloration, and other applicable characteristics. A 3 foot sample area of masonry joint is to be installed to demonstrate the color, texture, and tooling for approval by the A/E and the University Architect.

- .4 COURSING: Brick shall be laid with modular coursing, three courses to 8 inches, unless otherwise required to match existing coursing.

- .5 DESIGN: Face brick elevations shall include structural considerations for division of such elevations into panels to accomplish structural support of the brick face and expansion joints for control of thermal expansion damage. Designs, which include brick roof construction, shall not be used.

- .6 NON-STANDARD BRICK is prohibited.

## **DIVISION 04 - MASONRY**

---

- 04 21 00. CLAY FACING TILE: Select quality ceramic glaze, 8 W series.
- .1 REINFORCEMENT: Structural facing tile partitions shall be reinforced every second course with approved joint reinforcement.
- 04 22 00. CONCRETE UNIT MASONRY: Concrete block shall be used wherever feasible for interior wall finish. ASTM tests shall be indicated on all materials used below per Ohio Building Code requirements.
- .1 CINDER BLOCK: The use of cinder block is prohibited.
- .2 CONCRETE BLOCK, TYPES AND USES:
- .2.1 LOAD-BEARING - normal weight, standard size.
- .2.2 NON-LOAD-BEARING - lightweight, made with expanded shale aggregate and of standard size.
- .2.3 EXPOSED EXTERIOR - washed crushed limestone coarse aggregate and washed limestone sand, only, shall be used.

### **04 40 00. STONE**

- 04 40 20. CUT STONE:
- .1 LIMESTONE: Buff Indiana Oolitic limestone shall be used, except where other types might be required to match existing stone.
- .1.1 BACKS AND BONDING FACES shall be damp proofed with a water barrier as recommended by the Indiana Limestone Institute of America, Inc.
- .1.2 LIMESTONE SHALL BE NO CLOSER THAN 4-INCHES TO GRADE, when adjacent to lawns and planting areas.
- .1.3 SEALANT: Use a two-component, non-staining urethane elastomeric joint sealant for pointing stonework. Specify products that do not require priming of joint surfaces.
- .1.4 ANCHORS, DOWELS, AND OTHER ACCESSORIES used in setting stone shall be stainless steel.
- .1.5 HANDLING, PROTECTION, AND INSTALLATION shall comply with the recommendations of the Indiana Limestone Institute.
- .2 MARBLE: Marble shall be domestic. Edges of marble window stools shall be eased.
- .3 GRANITE: Granite shall be domestic. Granite may be specified for exterior stair treads when heavy traffic is anticipated.

---

END OF DIVISION 04 - MASONRY

## **DIVISION 05 - METALS**

2010 Edition, Published January 1, 2010; Division Revision Date: November 30, 2015

### **05 00 00. METALS**

#### **05 10 00. STRUCTURAL METAL FRAMING**

.1 GENERAL PROVISIONS: Use of ink marking pens on surfaces of any kind of materials is prohibited. Experience has shown that such marks bleed through paint and other finishes. Also prohibited are any marking devices that would leave residual material on metal surfaces, such as ink, wax-based or felt markers.

.2 POWER OR POWDER DRIVEN ANCHORS: Refer to Appendix V Section 01 35 23 Safety Health & Environment 1.6 USE OF POWER ACTUATED FASTENER TOOLS.

05 12 00. STRUCTURAL STEEL: Include a complete section in the specifications for this part of the work, in addition to the Structural Consultant notes on the drawings. The Architect/Engineer is responsible for complete coordination of statements in the specifications and the notes on drawings.

.1 PROVISIONS FOR VERTICAL EXPANSION: In buildings designed for future vertical expansion, structural steel shall be erected within tolerances stipulated in the AISC Code of Standard practice.

.2 AFFIDAVIT FROM ERECTOR: The General Contractor shall be required to provide an affidavit, at the completion of the job, to the effect that the structural steel frame is plumb and level within the normal tolerances specified in the code.

.3 RECORD OF ERECTION: The General Contractor shall provide a certified survey by a registered Civil Engineer showing the exact location of the centers and elevations of the columns at their topmost level, exactly as installed. This information shall be incorporated into the "record" drawings.

#### **05 20 00. METAL JOISTS**

.1 MANUFACTURER'S CERTIFICATE of compliance with Steel Joist Institute Specifications is required.

.2 PRIME COAT AND TOUCH-UP PAINTING will be considered adequate for joists, except where subjected to moisture or where exposed to view. Asphalt coatings are not permitted on metal joists that are to remain exposed and receive painted finish.

#### **05 30 00. METAL DECKING**

.1 MANUFACTURER'S CERTIFICATE of compliance with Steel Deck Institute Specifications is required.

.2 PRIME COAT AND TOUCH-UP PAINTING will be considered adequate for metal deck, except where subjected to moisture or where exposed to view.

## DIVISION 05 - METALS

---

### 05 40 00. COLD-FORMED METAL FRAMING

- .1 A manufacturer's certificate of compliance with American Iron & Steel Institute (AISI) specifications SG02-1 North American Specifications for the Design of Cold-Formed Steel Structural Members and SG-973 Cold-Formed Steel Design Manual is required.
- .2 COLD-FORMED METAL STUD SYSTEM: Studs and furring strips shall be spaced 16 inches on center, maximum.

### 05 50 00. METAL FABRICATIONS

- .1 GALVANIZING REQUIREMENTS: All exterior ferrous metals shall be hot-dip galvanized after fabrication.
- .2 MISCELLANEOUS METAL FRAMING FOR ELECTRICAL SUPPORT SYSTEMS: If electrical equipment is attached to support framing, the Electric Contractor will provide and install that metal framing. See Facility Services-3.15.
- .3 LINTELS FOR PLUMBING, HVAC, AND ELECTRICAL INSTALLATIONS: Specify that the General Contractor furnish lintels for all openings through walls when openings are shown on the architectural or structural (General Contract) drawings. Note all such lintels and openings to require coordination of work and exact locations, by affected contractors. All such plumbing, HVAC, electrical, and sprinkler openings must be coordinated and shown on the Architectural and/or Structural Drawings.

### 05 51 00. METAL STAIRS:

- .1 STAIR TREADS FOR PUBLIC-ACCESS STAIRWAYS shall be concrete with cast metal nosings. Nosings shall be shaped to a radius; square nosings are prohibited.

**STUDENT LIFE: Metal stairs shall be stainless steel in high traffic or high visibility areas with concrete stair treads and cast metal nosing.**

- .2 STAIR TREADS FOR ROOF ACCESS, EQUIPMENT ROOM ACCESS, AND LADDERS shall be metal with each tread to be the full width of the stair or ladder. Alternating treads are prohibited.
- .3 A MANUFACTURER'S CERTIFICATE of compliance with the Architectural Products Division of the National Association of Architectural Metal Manufacturer's AMP 510 Metal Stairs Manual materials, construction and installation specification is required.
- .4 Metal pan stair treads and landings filled with concrete, terrazzo, etc. shall be prohibited for exterior stairs. Special permission from the University Engineer is required for use of metal pan stair treads and landings for interior main entry stairs.

05 53 00. GRATINGS: Ferrous gratings shall be hot-dip galvanized and designed to support a minimum live load of 100 pounds per square foot. Galvanized hardware cloth shall be installed under all areaway gratings.

- 1. A MANUFACTURER'S CERTIFICATE of compliance with ANSI/NAAMM National Association of Architectural Metal Manufacturer's MGB531 Metal Bar Grating Manual materials, construction and installation specification is required.

END OF DIVISION 05 – METALS

## **DIVISION 06 - WOOD, PLASTIC, AND COMPOSITES**

2010 Edition, Published January 1, 2010; Division Revision Date: February 28, 2014

### **06 00 00. WOOD, PLASTIC, AND COMPOSITES** **06 00 03. GENERAL PROVISIONS**

- .1 USE OF INK MARKING PENS ON SURFACES of any kind of materials is prohibited. Experience has shown that such marks bleed through paint and other finishes.

### **06 05 73. WOOD TREATMENT**

- .1 PROTECTION AGAINST DECAY: Wood used in conjunction with roofing installations, canopy structures, and wood which is installed in contact with concrete or masonry shall be pressure treated with an approved preservative to meet American Wood Preservers Association (AWPA) Standards. Other installations shall receive prime coats suitable for finishes specified as soon as installations are completed. Back prime where dampness or warping is anticipated. Wood preservatives containing arsenic such as Chromated Copper Arsenate (CCA) for exterior construction above ground or in ground contact or fresh water is generally prohibited unless the treated materials meet EPA regulatory requirements of structural members.

**Commentary:** *Structural posts of "post frame" type construction in agricultural applications may be CCA treated wood.*

- .2 The minimum chemical retention (lbs / cubic foot) for wood above ground is to be 0.25, for wood in contact with the ground or fresh water immersion is 0.40, and wood in the ground (structural) 0.60.
- .3 After cutting treated lumber, the cut end is to be retreated.
- .4 All wood blocking, sawn lumber and plywood shall be fire resistant treated.

### **06 10 00. ROUGH CARPENTRY**

- .1 WOOD FRAMING: Stud and furring strip shall be fire resistant treated and spaced 16 inches on center, maximum.

### **06 13 00. HEAVY TIMBER**

- .1 TIMBER TRUSSES: With the shop drawings, a complete design analysis of structural components shall be submitted. Data shall bear the seal and signature of a professional engineer, registered in Ohio, attesting that the design of trusses meets requirements of the Ohio Building Code (OBC) and design loadings.

### **06 17 00. SHOP-FABRICATED STRUCTURAL WOOD**

- .1 WOOD TRUSSES: Same as 06 13 00.1.above.

### **06 20 00. FINISH CARPENTRY**

- .1 MATERIALS AND FABRICATION: Conform to Architectural Woodwork Institute specifications for Custom quality work.

## **DIVISION 06 – WOOD, PLASTIC AND COMPOSITES**

---

### **06 22 00. MILLWORK**

- .1 MATERIALS AND FABRICATION: Refer to the Architectural Woodwork Institute “Quality Standards”, latest edition. Use “Custom Grade” for standard woodwork. Use “Premium Grade” for unique and special projects or features within a project.
  - .1.1 The Space in which millwork is to be installed needs to be engineered with appropriate humidity controls to maintain optimum relative humidity of 25-55%.
  - .1.2 Wood for architectural use needs moisture content within the optimum range of 5-10%.

### **06 40 00. ARCHITECTURAL WOODWORK**

- .1 CABINET WORK: Materials and fabrication shall conform to Architectural Woodwork Institute specifications for Premium quality work. Written certification is required from the fabricator that Architectural Woodwork materials, construction and installation comply with the specified standards.
  - .1.1 The Space in which Architectural Woodwork is to be installed needs to be engineered with appropriate humidity controls to maintain optimum relative humidity of 25-55%.
  - .1.2 Wood for architectural use needs moisture content within the optimum ranges of 5-10

**END OF DIVISION 06 – WOOD AND PLASTIC**

## **DIVISION 07 - THERMAL AND MOISTURE PROTECTION**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **07 00 00. THERMAL AND MOISTURE PROTECTION**

#### **07 10 00. DAMPPROOFING AND WATERPROOFING**

.1 Calculations shall be provided to demonstrate that the dew point of all foundations/roofs/walls with waterproofing falls on the outside of the building.

#### **07 11 00. DAMPROOFING**

.1 FOUNDATION WATERPROOFING: Shall be provided at all below grade vertical and horizontal surfaces.

.2 EXPOSED BITUMINOUS TYPE: Shall not be allowed on surfaces of exterior walls and walls below grade.

07 12 00. WATERPROOFING: The following are minimum requirements to assure adequately designed waterproof floors for machine and equipment rooms and other areas subject to flooding from equipment failure or seepage from exterior sources:

.1 DRAWINGS shall fully detail the installation of the membrane. Continuous membrane risers shall be provided above the finished floor surface at vertical walls, pads, curbs, pipes, and ducts through the slab. All floor penetrations must be sleeved to a height of 4" above the finished floor. Risers shall be at least as high as the lowest curb and shall be bonded to the vertical surface. Concrete foundation walls around elevator pits and around basements, from grade to footings, shall be treated with membrane waterproofing. When elevators open into mechanical rooms and other areas subject to flooding, opening sills must be 4" above the finished floor to keep flood water out of elevator shaft. A concrete ramp shall be constructed from the elevator door sill to the floor level.

.2 SPECIFICATIONS shall provide for a heavy duty, permanent waterproofing type of membrane capable of adjusting to building movements without breaking the membrane seal. When rubber or plastic membranes are specified, a five (5)-year experience clause with written documentation by the installer shall be required in the specification.

.3 TIMING OF INSTALLATIONS: When surface applied membrane waterproofing is specified, the specification must prohibit scheduling of installation until after the major work of all other trades has been completed. Inaccessible surfaces under equipment and housing foundations, pads, and curbs shall be waterproofed in advance of floor areas. Surface membrane must be protected until acceptance of the space by the University. Surface applied membrane, except under equipment, must be accessible for repair.

.4 TESTING: Specifications shall provide for the testing of waterproofed membrane floors by flooding. Floors shall be filled with water to within 1/4 in. of top of lowest curb for a period of 6 hours and closely inspected for leaks; tests shall be witnessed by designated representatives of the University. The test shall not relieve the contractor of maintaining a leak free floor until the end of the warranty period.



## **DIVISION 07 - THERMAL AND MOISTURE PROTECTION**

---

- .5 MAINTENANCE GUARANTY: The General Contractor, manufacturer and installing subcontractor shall furnish a written three (3) year guaranty on the complete membrane waterproofing installation. Submit the guaranty in triplicate. The guaranty shall begin when the space is completed and accepted for use by the University.

The guaranty shall cover, at no cost to the University, all labor and materials required for repair or replacement to correct leaks, faulty materials or workmanship.

- 07 19 00 WATER REPELLENTS: Water repellent coatings on exposed surfaces of exterior – concrete block, and precast concrete shall be coated with a penetrating colorless, non-staining, mildew-resistant water repellent applied by an applicator experienced with the material applied. The product shall include a ten (10)-year warranty and will be vapor permeable to allow moisture to escape from inside of the wall.

Water repellent coatings on brick, limestone and sandstone are prohibited for all buildings where the wall system is a mass masonry system.

### **07 20 00. THERMAL PROTECTION**

- 07 22 00. ROOF DECK INSULATION: All insulating materials, including cant strips and tapered edge strips, shall be non-hygroscopic. Wood fiber composite insulation is prohibited. A suitable cover board as recommended by the National Roofing Contractors Association (NRCA) shall be installed over all polyisocyanurate type insulation board. Compatibility with roofing materials or separation is mandatory for wood, treated wood, fibrous materials, insulation, etc. See 07 50 10.5. and 07 50 10.6.

- .1 Fire resistance rated polysocyanurate roofing board insulation shall use non-halogenated flame retardants.

- 07 24 00. EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS): These materials are not allowed for use on University projects without the express written consent of the University Architect.

### **07 31 00. SHINGLES AND ROOFING TILES**

- 07 31 13. ASPHALT ROOF SHINGLES

- .1 ASPHALT ROOF SHINGLES: Specify only wind resistant type 280# or greater. Fire-resistant rating shall be UL Class A. Install shingles and roofing tiles per requirements of the OBC and manufacturer's maximum recommended quality standards for the deck to be roofed. The shingle installation shall conform to the National Roofing Contractors (NRCA) Steep Roofing Manual recommendations. Sheet metal shingle flashing installations for asphalt roof shingle projects shall conform to the Sheet Metal and Air Conditioning Contractors National Association, Inc (SMACCCNA) Architectural Sheet Metal Manual recommendations.

**OARDC:** The use of 240# asphalt singles that meet ASTM D3161 and ASTM D7158, Class F (110 MPH) or higher wind speed ratings is permitted.

- .2 Use of *pneumatic* powered nails or staples is prohibited.

**OARDC:** The use of staples is prohibited but pneumatic roofing nailing per the project specifications and the requirements of Appendix V- Safety health and Environment is permitted.

## **DIVISION 07 - THERMAL AND MOISTURE PROTECTION**

---

.3 Warranty of shingles shall be a minimum of 30 years and applicator's warranty shall be for Two (2) years.

.4 Shingle underlayment shall be an Ice/Water Guard type self-adhering underlayment. 15# and 30# felt are prohibited.

### **07 31 26. SLATE SHINGLES**

.1 Slates shall be natural slate; artificial slate is **prohibited**. Underlayment shall be an Ice/Water Guard-type self-adhering underlayment. The shingle installation shall conform to the National Roofing Contractors (NRCA) Steep Roofing Manual recommendations. Sheet metal shingle flashing installation for slate shingles shall conform to the Sheet Metal and Air Conditioning Contractors National Association, Inc (SMACCNA) Architectural Sheet Metal Manual recommendations.

### **07 32 13 Clay ROOFING TILES**

.1 Tiles shall be clay only. Underlayment shall be an Ice/Water Guard-type self-adhering underlayment, with coverage based on structural assemblies permeability requirements. The roofing tile installation shall conform to the National Roofing Contractors Association (NRCA) Steep Roofing Manual recommendations. Sheet metal shingle flashing installation for a clay tile installation shall conform to the Sheet Metal and Air Conditioning Contractors National Association, Inc (SMACCNA) Architectural Sheet Metal Manual recommendations.

### **07 40 00. PREFORMED ROOFING AND SIDING PANELS**

.1 Preformed roofing underlayment shall be an Ice/Water Guard type self-adhering underlayment. 15# and 30# are prohibited. Acceptable types of preformed roofing and siding materials and finishes are metal materials with a natural finish (copper), anodized finish (aluminum) or painted finish (aluminum or steel).

.2 **PREFORMED WALL AND ROOF PANELS:** Finish materials and colors for roof structures and rooftop equipment screens are subject to the approval of the University Architect.

### **07 50 00. MEMBRANE ROOFING**

#### **07 50 10. GENERAL REQUIREMENTS:**

.1 **DESIGN REQUIREMENTS FOR MEMBRANE ROOFING:** Roof decks must be built with a slope of at least 1/4 in. per ft. toward drains. Dead level roofs are prohibited. Use of Emergency relief drains is prohibited. Scupper openings shall be provided through parapet walls complying with all applicable requirements of the OBC in lieu of relief drains. Ensure that drains are truly at low points of roofed area. Install "crickets or saddles" to divert water flow around curbs so as to avoid interference with designed drainage system. "Crickets and saddles" shall be installed behind curbs with a dimension of 24 inches or greater measured perpendicular to the slope of the roof. Reroofing projects will require individual assessment for design to provide adequate drainage slope.

.2 **OBSERVATION OF INSTALLATION BY UNIVERSITY PERSONNEL:** The University shall be given 2 weeks advance notice of intent to start installation of roofing materials. Designated University personnel must be permitted to perform a pre-installation inspection of roofing materials and equipment, to be present throughout roofing installation to observe installation techniques for compliance with specifications and to participate in final inspection. Questionable installations will be brought to the attention of

## DIVISION 07 - THERMAL AND MOISTURE PROTECTION

---

the Architect/Engineer (A/E) who shall take immediate action to correct any deficiencies in materials or installation. Failure of OSU personnel to call attention to deficiencies shall not relieve the contractor of responsibilities stipulated in the Maintenance Guaranty.

- .2.1 CUTTING OF TEST PANELS: The University reserves the right to cut test panels from the finished roof in order to determine that minimum requirements have been met. The roofer shall repair, at his own expense, the roof where test panels were taken.
- .3 COORDINATION OF INSTALLATIONS: The roofer shall install all flashings and insulation required to make a complete waterproof installation. For this reason, it is preferred that specifications for roofing, insulation, flashing, and sheet metal work be combined into one section. Although certain counter flashings or similar materials may be provided by other contractors, the roofer shall be made responsible for their proper installation. Also see BDS Divisions 21-28 Facility Services-Document Requirements 3.16 (Roof Mounted Equipment, Flashing and Roof Penetrations).
- .4 GUARANTY: Insert the following paragraphs in the specifications:
- .4.1 ROOFING AND FLASHING GUARANTY: The manufacturer(s) of materials used shall furnish a written twenty (20) year guaranty on the complete roof installation. Submit the guaranty in triplicate. The guaranty shall begin when the project is completed and accepted by the University.
- .4.2 GREEN ROOF WARRANTY: Manufacturer's single-source written twenty (20) year warranty on the full green roof assembly. Submit the warranty in triplicate. The warranty shall begin when the project is completed and accepted by the University.
- .4.3 The general contractor and the roofing subcontractor shall furnish a two (2) year maintenance warranty on the total roofing system. The guaranty shall cover, at no cost to the University, all labor and materials required to repair or replace roofing, flashings, sheet metal and copings as necessary to fully correct leaks, faulty workmanship or defective materials.
- .5 STORAGE OF MATERIALS: Roofing felts, membranes and insulation are to be stored in a dry trailer or inside a dry building. Exterior storage on skids or tarpaulin coverage is unacceptable. Asphalt or coal tar pitch may be stored outside if kept under a tarpaulin or plastic film.
- .6 WET MATERIALS: Roofing felts or insulation which became wet before or after installation must be removed and replaced. Wet materials shall not be dried and reused. Wetted membrane materials must be thoroughly evaluated to determine the effect on adhesion, lap seals or blister potential. Remove any such material if there is any possibility of failure.
- 07 51 00. BUILT-UP BITUMINOUS ROOFING: No less than four (4) ply construction may be specified. Conform strictly with the manufacturer's recommendations for installation. A fume control system approved by the University architect/engineer project representative is required.
- 07 53 00. ELASTOMERIC MEMBRANE ROOFING: See 07 54 00 for recommended membrane roofing systems. Other types allowed with written approval are: Ethylene Propylene Diene Monomer (EPDM)
- 07 54 00 THERMOPLASTIC MEMBRANE ROOFING: Thermoplastic Polyolefin (TPO), DuPont Elvaloy Ketone Ethylene Ester (KEE), Polyvinyl Chloride (PVC) roofing systems with heat welded seams are recommended. - No ballasted roof systems permitted.

## **DIVISION 07 - THERMAL AND MOISTURE PROTECTION**

---

- .1 MODIFIED BITUMEN SHEET ROOFING: Systems composed of at least two plies, one of which can be a heavy base sheet, are preferred. Mineral (granule) surface weathering is preferred.
- .2 CLEAN UP: Emphasize that debris not be allowed to accumulate on roof during construction. All debris shall be totally removed at completion of project.
- 07 56 00 FLUID-APPLIED ROOFING: Not permitted. However, liquid-applied reinforced polymeric membranes may be approved on a case by case basis.

### **07 60 00. FLASHING AND SHEET METAL**

#### **07 60 10. GENERAL REQUIREMENTS:**

- .1 FLASHING GUARANTY requirements apply to this work. Note that curb heights must comply with manufacturer's requirements for warranty of roofing systems. Refer to paragraph 07 50 10.4.
- .2 PLUG ANCHORAGE: \_ use of wood, or plastic is prohibited.
- .3 FASTENERS: For preservative-treated and fire retardant-treated lumber, and High Humidity Area fasteners shall be stainless-steel connectors and fasteners (Type 304 or 316 stainless steel), copper or silicone bronze fasteners. Mechanically galvanized fasteners and connectors are prohibited. Fastener metal type for flashings shall match the flashing metal type. Expansion type fasteners are prohibited for use in stone and brick. Fasteners in masonry shall be installed in the mortar joints, or where required to be in the masonry unit, shall be drilled and set in epoxy.
- .4 METAL FLASHING: Copper, soft temper stainless steel, terne coated or stainless steel. No aluminum or galvanized steel.
- .5 PITCH PAN OR POCKETS: Use of pitch pans or pockets only if approved by the University Architect. Items penetrating roofing must be flashed with sheet metal secured with stainless steel clamps or with box curbs welded, or otherwise secured, to the penetrating items. See flashing materials above for acceptable metals.
- .6 FLASHING AND SHEET METAL: Fabrication and installation conform to the latest edition of Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA) Architectural Sheet Metal Manual recommendations. Copper, when used, to conform to SMACNA and to the latest edition of Revere Copper Products, Inc. Copper & Common Sense recommendations.
- .7 No power or powder driven tools to be used unless approved for use by the Office of Environmental Health and Safety -. See Appendix V: 01 35 23 – 1.6.
- .8 ROOF PROTECTION: See 01 71 33.1 ROOF PROTECTION

### **07 70 00. ROOF AND WALL SPECIALTIES AND ACCESSORIES:**

## **DIVISION 07 - THERMAL AND MOISTURE PROTECTION**

---

.1 GUTTERS AND DOWNSPOUTS: Copper, stainless steel, or baked enamel steel. No aluminum or galvanized steel.

.2 FASCIAS AND GRAVEL STOPS: Aluminum, copper, stainless steel, or baked enamel coated steel.

07 72 00. ROOF ACCESSORIES:

.1 ROOF WALKWAYS: Provide per roof system manufacturer's specifications.

.2 ROOF HATCHES: Roof hatches shall have guardrails with spring loaded swing gates.

.3 ELECTRIC FIELD VECTOR MAPPING (EFVM): Specify an EFVM system for all approved green roof assemblies.

### **07 75 00 LIGHTNING PROTECTION**

.1 Refer to Division 26 for Lightning Protection requirements.

### **07 81 00 APPLIED FIREPROOFING**

.1 QUALITY ASSURANCE:

A. Installer Qualifications: Engage an experienced installer certified, licensed, or otherwise qualified by the sprayed fire-resistive materials manufacturer as having the necessary experience, staff, and training to install manufacturer's products per specified requirements. A manufacturer's willingness to sell its sprayed fire-resistive material products to the Contractor or to an installer engaged by the Contractor does not in itself confer qualification on the buyer.

1. Industry standard installation requirements such as NFCA – 100, "Standard Practice For The Application of Spray-Applied Fire Resistive Materials (SFRMs)

B. Single-Source Responsibility: Obtain spray-applied fire resistive materials from a single manufacturer for each different product required.

C. Provide fireproofing products containing no detectable asbestos as determined according to the method specified in 40 CFR Part 763, Subpart F, Appendix A, Section 1, Polarized Light Microscopy.

1. Spray-applied fire resistive materials shall be free of all forms of asbestos and asbestos contamination, including actinolite, amosite, anthophyllite, chrysotile, crocidolite and tremolite.

2. Manufacturer shall provide Certification that products supplied are 100% asbestos-free.

D. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Test and inspect as required by the Ohio Building Code, 1704.12.

E. Surfaces to be protected shall meet applicable requirements for application and adhesion characteristics.

## **DIVISION 07 - THERMAL AND MOISTURE PROTECTION**

---

- F. Protect all architectural finishes from over spray.
- G. Sealer for Spray Applied Fire Resistive Materials: Transparent-drying, water-dispersible, tinted protective coating recommended in writing by manufacturer of spray applied fire resistive materials.

### **.2 INFORMATION SUBMITTALS**

- A. Product certificates.
- B. Evaluation / special inspection reports.
- C. Field quality-control reports.
- D. Include the above A., B., & C. items in the Operations & Maintenance Manuals in both electronic and hard copy. Also, provide copies to the Office of Environmental Health and Safety (EHS).

### **.3 REPLACEMENT OF EXISTING ASBESTOS CONTAINING SPRAY APPLIED FIRE RESISTIVE MATERIALS:**

- A. Replacement fireproofing materials to be a light blue color to easily be identified and differentiated from the remaining spray applied fire resistive materials.
- B. Replacement spray applied fire resistive materials are required to be compatible with existing conditions.
- C. Following abatement use a lock down agent that is UL Classified for use with the replacement fireproofing.
- D. Identification Labeling:
  - a. Label the remaining asbestos containing fireproofing "ACM."
  - b. Label the new non-asbestos containing fireproofing "Non-ACM"

## **07 90 00. JOINT PROTECTION**

07 90 10. GENERAL REQUIREMENTS: The following conditions shall be included in the specifications:

- .1 GUARANTY: Provide written guaranty that the sealant manufacturer, General Contractor and sealant installer jointly guarantee to replace, at no cost to the University, any or all joints which fail to establish and maintain airtight and watertight continuous sealed joints without staining or deteriorating joint substrates within:
  - a. 20 - years after acceptance for silicone building sealants.  
*Commentary: A 5- year guarantee is acceptable when the 20 – year guarantee would add additional project costs. In either case require that adhesion pull tests be performed*
  - b. 5 years after acceptance for polyurethane sealants.

## **DIVISION 07 - THERMAL AND MOISTURE PROTECTION**

---

- .2 QUALIFICATIONS OF APPLICATOR: Sealants shall be applied by specialists in the application of sealants; minimum 5 years experience required. Applicator is subject to the A/E's approval.
- .3 RESPONSIBILITY FOR SATISFACTORY APPLICATION: Inspect work of other trades prior to application of sealing material. If any joint or space cannot be put into proper condition to receive the material by specified methods, immediately notify the A/E in writing, or assume responsibility for and rectify unsatisfactory results from improper application.
- .4 TIME AND TEMPERATURE REQUIREMENTS: Apply sealants as late as possible in the construction, preceding painting, and following cleaning operations. Do not apply sealants when air temperature is below 40 degrees F.
- .5 DO NOT SAY CAULK OR CAULKING NOR USE THOSE MATERIALS.

### 07 92 00. JOINT SEALANTS

- .1 INTERIOR: Use acrylic type suitable for application of paint.
- .2 EXTERIOR: Use of silicone sealant is preferred, where applicable based on material types over polyurethane sealants. Prior to construction, require manufacturer's compatibility and adhesion test results for exterior elastomeric joint sealants on building materials which are subject to significant movement.

*COMMENTARY: It is recommended that the A/E review SMACNA ARCHITECTURAL SHEET METAL MANUAL (CURRENT EDITION) Appendix M GENERAL GUIDE TO JOINT SEALANTS FOR ARCHITECTS, Appendix A Sample Specification Information, Appendix B Relevant Standards and Appendix C Additional Resources.*

END OF DIVISION 7 - THERMAL AND MOISTURE PROTECTION

## **DIVISION 08 – OPENINGS**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **08 00 00. OPENINGS**

#### **08 00 03. GENERAL PROVISIONS**

- 08 00 10. ALL EXTERIOR DOORS shall be metal, existing historical buildings are to be reviewed on a case by case basis (e.g. but not limited to, Orton Hall, Hayes Hall, Hale Hall, Pomerene Hall, Hamilton Hall, etc.), and be equipped with pull handles per 08 70 30.3 and overhead surface mount door stops.
- 08 00 20. MULTIPLE EXTERIOR DOORS shall have fixed mullion separations except that at least one pair of doors shall have a removable mullion for equipment access. Also see 08 70 30.6.
- 08 00 30. DOORS FOR USE BY PERSONS WITH DISABILITIES.
- .1 One door at each primary point of ingress and egress shall be equipped with a power door operator unless the entrance is not accessible.
- .2 Refer to 08 72 00, confer with the Facilities Operations and Development's ADA Coordinator on Power Door Operators.
- .3 Revolving doors at entrances, darkrooms and other restrictive locations require provision for alternative means of access.
- 08 00 40. LABELED CONSTRUCTION AND LABELS shall be provided where required by the building code.
- 08 00 50. TRASH ROOM DOORS shall be no less than 3'-6" wide.
- 08 00 60. USE OF INK MARKING PENS ON SURFACES of any kind of materials is prohibited. Experience has shown that such marks bleed through paint and other finishes.
- 08 00 70. POWER OR POWDER DRIVEN ANCHORS refer to Appendix V Section 01 35 23 Safety Health & Environment 1.6 USE OF POWER ACTUATED FASTENER TOOLS -
- 08 00 80. DEMOLITION / REMODELING: Lock and door hardware removals shall be coordinated with Facilities Operations and Development's Lock & Key Services. All cylinders and cores removed shall remain the property of The Ohio State University, and are to be returned to FOD's Lock & Key Services.

#### **08 10 00. DOORS AND FRAMES**

##### **08 11 13. HOLLOW METAL DOORS AND FRAMES**

- .1 EXTERIOR DOORS shall be not less than 16-gauge hot dipped zinc-coated steel sheets (Galvannealed) meeting ASTM A653, zinc-iron alloy-coated, with A60 coating. The top channel of each metal door shall be turned web up, to avoid a dirt pocket or moisture trap. Full glazed doors shall have 12-inch bottom rails. "High Frequency" hinge preparation and reinforcement is required.
- .2 INTERIOR DOORS shall be not less than 18-gauge metal. Full glazed doors shall have 12-inch bottom rails.
- .3 ACCESS DOORS shall be provided at plumbing chases, building equipment maintenance corridors, interstitial spaces, and in ceiling areas. Coordinate with



Plumbing, HVAC and Electrical Contractors. Access door locking devices shall be equipped with approved cylinders per 08 71 90.3 and 08 71 90.4 and accept Stanley Security Solutions small format 7-pin interchangeable core. Following approval by FOD's Lock & Key Services of the final keying schedule, Stanley Security Solutions will combine permanent cores, cut, and tag one key per core and deliver cores and keys directly to FOD's Lock & Key Services for installation. The type of access doors are to be reviewed and approved by Facilities Design and Construction. The supplying contractor of the cylinder and lock cores shall provide their contact name, address, phone number with the product submittal and a copy shall be provided by the A/E to FOD's Lock & Key Services.

.3.1 The Architect/Engineer (A/E) shall place in the specifications that the Contractor supplying the Access Doors shall enter into an agreement with Facilities Operations and Development's (FOD's) Lock & Key Services to install the final cores during the construction period. Provide an allowance for this work after consulting with FOD's Lock & Key Services for current/project charges per core (approximately 1/10 hour per core at the University's current Skilled Craft Rate.)

.4 HOLLOW METAL FRAMES shall be one-piece, welded frames of not less than 16-gauge hot dipped zinc-coated steel sheets (Galvannealed) meeting ASTM A653, zinc-iron alloy-coated, with A60 coating for interior doors. Frames in interior walls through 8-inch thickness shall be full width of wall. Knock-down frames are generally prohibited; however, such frames may be used in movable partitions. In remodeling work, permission will be granted by the University Architect to use knock-down frames if conditions justify their use. Frames for exterior doors shall be one-piece, welded frames of 14-gauge or heavier metal. All entrance door frames shall be heavily reinforced at hinge, strike and closer locations for "High Frequency" use. Frames shall have a hot dipped zinc coating.

08 11 16. ALUMINUM DOORS AND FRAMES

.1 Aluminum doors and frames shall be factory finished.

**08 14 00. WOOD OR PLASTIC LAMINATE FACED WOOD DOORS**

.1 All wood doors shall be at least 1-3/4" thick to accommodate mortise locks.

08 14 10. GUARANTEE: Interior doors, except some fire rated doors, shall be flush type, solid core, hardwood, with lifetime guarantee. Guarantee shall include removal, new door finishing, and hanging of doors at no cost to the University.

08 14 20. FIRE RATED DOORS

.1 2 hr. (120-minute), 1-1/2 hr. (90-minute), 3/4 hr. (45-minute) and 20-minute doors must have a U.L. label per NFPA Pamphlet 80.

.2 MINERAL CORE LABELED DOORS ARE PROHIBITED because the narrow rails and stiles, required to obtain U.L. approval, are expected to reduce the service life and security of these doors in rigorous service.

08 14 30. WOOD VENEERS: Judicious selection of face veneers shall be exercised. The contractor shall be required to make a grain selection, prior to placing wood doors in the more prominent or public places, subject to the approval of the Architect/Engineer (A/E). Wood doors in, or adjacent to, wood paneling will have veneers to match the paneling.

## **DIVISION 08 – OPENINGS**

---

### **08 30 00. SPECIAL DOORS**

- .1 ACCESS DOORS TO MACHINE AND EQUIPMENT SPACES shall be hollow metal doors in 4-sided steel frames, minimum size 2'-0" by 4'-0". All access doors locking devices shall be equipped with cylinders per 08 71 90.3 and 08 71 90.4 and accept Stanley Security Solutions small format 7-pin interchangeable core. Following approval by FOD's Lock & Key Services of the final keying schedule, Stanley Security Solutions will combine permanent cores, cut, and tag one key per core and deliver cores and keys directly to FOD's Lock & Key Services for installation.
- .2 The Architect/Engineer (A/E) shall place in the specifications that the Contractor supplying the Access Doors shall enter into an agreement with Facilities Operations and Development's (FOD's) Lock & Key Services to install the final cores during the construction period. Provide an allowance for this work after consulting with FOD's Lock & Key Services for current/project charges per core (approximately 1/10 hour per core at the University's current Skilled Craft Rate.)

### **08 40 00. ENTRANCES, STOREFRONTS, AND CURTAIN WALLS**

#### **08 42 00. ENTRANCES**

- .1 All doors shall be equipped with top and bottom rails and door stiles with the following minimum dimensions:  
Dimensions of components shall be at least:  
Metal thickness - 1/8 inch  
Head rail size - 6-1/2 x 1-3/4 or 6 x 2 inches  
Stile size - 5-1/2 x 1-3/4 or 5 x 2 inches  
Bottom rail size - 12-1/2 x 1-3/4 or 12 x 2 inches  
Hardware reinforcement - 1/4 inch thick metal material
- .2 Doors shall be fully glazed. Glass for exterior doors and all sidelights shall be 1/4-inch thick laminated fully tempered insulated glass units.
- .3 Doors may have a mid-rail located at the center of the exit device.
- .4 ENTRANCE FRAMES:  
Dimensions of components shall be at least:  
Metal thickness - 1/8 inch  
Head size - 4-1/2 x 1-3/4 or 4 x 2 inches  
Jamb size - 4-1/2 x 1-3/4 or 4 x 2 inches  
Hardware reinforcement - 1/4 inch thick metal material

### **08 50 00. WINDOWS**

- .1 DESIGN FOR ENERGY CONSERVATION: Refer to PART ONE, paragraph 00034, and Facility Services-6. When practical, windows shall be provided with operable vent sections to obviate for the need conditioned air. All aluminum windows shall have a thermal break and be certified and labeled with AAMA certification, existing historical buildings with steel windows are to be reviewed on a case by case basis (e.g. but not limited to, Orton Hall, Hayes Hall, Hale Hall, Pomerene Hall, McCracken Power Plant, Faculty Club, Ramseyer Hall, Stillman Hall, etc.).

- 08 50 10. CUSTOM WINDOWS: The following requirements shall be included in the specifications:

## **DIVISION 08 – OPENINGS**

---

- .1 **PERFORMANCE REQUIREMENTS:** The manufacturer shall submit copies of reports of tests made on previously manufactured windows of the same type to be furnished for this project, made or witnessed by an independent testing laboratory and showing conformance to the following performance standards:
  - .1.1 Air infiltration of an assembled sash and frame shall not exceed 0.15 cubic feet per minute, per foot of sash perimeter, when the window is subjected to a static pressure equivalent to a wind velocity of 50 miles per hour.
  - .1.2 There shall be no apparent water leakage to the interior side of the window when tested for fifteen minutes with water spray at a rate of five gallons per square foot per hour under a pressure equivalent to a wind velocity of 50 miles per hour.
  - .1.3 All aluminum windows shall have a thermal break and be certified and labeled with AAMA certification.
- .2 **WINDOW GLAZING METHOD:** Windows shall preferably be designed for glazing from inside only; for other methods of glazing, confer with the University Architect.
- .3 **DESIGN:** Avoid sliding and double-hung sash; use hoppers and types with compression gaskets.
- .4 **GUARANTEE:** Provide a written guarantee that all parts of the installation will meet specified performance requirements and will be free from defects in materials and workmanship for a period of five years following acceptance. Weatherstripping shall be guaranteed for a period of five years. Guarantee shall certify that all work is in accordance with the Contract Documents and shall contain a statement that, should any defects develop during the guarantee period, caused by improper workmanship or materials, such defects will be repaired or windows will be replaced at no expense to the University.
- .5 **TESTING:** Field testing of non-standard installed windows may be required by the University.
- .6 **CLAD WINDOWS** (clad with vinyl or aluminum on the exterior) are prohibited unless special permission is received from the University Architect in writing.

### **08 60 00. ROOF WINDOWS AND SKYLIGHTS**

- .1 **SKYLIGHTS** are prohibited unless special permission is received from the University Architect in writing.

### **08 70 00. HARDWARE**

- 08 70 10. **SPECIFICATIONS FORMAT:** It is preferred that this section include all items of finish hardware, including items listed in the CSI MASTERFORMAT, with the exception of window operators, which should be included with section in which windows are specified. Such a format will facilitate the writing of hardware specifications in the form usually used by Architectural Hardware Consultants.
- 08 70 20. **PROHIBITED MATERIALS AND INSTALLATIONS:**
  - .1 **THRESHOLDS RAISED ABOVE FLOOR LEVELS** at doors to trash and receiving rooms and over 1/2-inch high at doors along routes that are otherwise accessible or those intended for use of persons with disabilities.

## DIVISION 08 –OPENINGS

---

- .2 FLOOR MOUNTED DOORSTOPS.
  - .3 DOORKNOBS OR LEVERS CONTAINING LOCK CORES OR KEYING DEVICES.  
**OARDC:** OARDC permits cylinder locksets with integral cores in accepted interior locations. Consult with the Project Manager and OARDC for the acceptable locations.
  - .4 FLOOR CLOSERS AND CLOSERS CONCEALED IN DOOR HEADS.
  - .5 DOOR CLOSERS WITH INTEGRAL SMOKE DETECTORS: Smoke detection systems must be made a part of the documents for Fire Detection and Alarm per 28 31 00.
  - .6 ALL CONCEALED VERTICAL ROD EXIT DEVICES. Surface mount vertical rods, less bottom rods, are permitted only with approval of Facilities Operations and Development's (FOD) Lock & Key Services and only on openings when typically held open and automatically released upon fire alarm.
  - .7 PASSIVE INFRARED (PIR) MOTION DETECTORS at door location for request to exit on alarmed doors.
  - .8 SECTIONAL TRIM on mortise locksets.
  - .9 All electrified vertical rod exit devices.
  - .10 All sliding doors and "Pocket doors."
  - .11 All doors and hardware not specifically prohibited or approved in these standards shall be submitted to Facilities Operations and Development's Lock & Key Services for approval prior to being specified.
  - .12 Roller Latches.
- 08 70 30. GENERAL REQUIREMENTS:
- .1 ALLOWANCE: Consult the University Architect regarding provisions for a contingency allowance to cover items inadvertently omitted in hardware schedules. Provisions for this allowance might be particularly desirable for remodeling projects in which some existing hardware is scheduled for reinstallation. Allowance stipulated should not exceed 1/2 of 1 percent of the estimated cost of contract subdivision for finish hardware. Permission to specify this allowance shall in no way relieve the Architect/Engineer (A/E) of responsibility to furnish a complete and accurate hardware schedule.
  - .2 HARDWARE FOR ENTRANCE DOORS: All hardware for such doors shall be furnished by the hardware supplier. Weather seals for aluminum entrance doors shall be provided by the door supplier. With the exception of hardware furnished and installed by the door manufacturer, all hardware for such doors shall be furnished under this section. Specify that hardware supplier furnish, to the door manufacturer, templates or the actual items of hardware for which cutouts and signage are required.
    - .2.1 All exterior doors shall have full perimeter weather seals, including door sweeps.
  - .3 PULLS: Bases for grips shall project straight out, perpendicular to face of door. No curved bases.

## DIVISION 08 – OPENINGS

---

- .4 QUALITY AND DESIGN: Hardware must be adequate for the intended use and must satisfy code requirements, but shall not be excessively sophisticated or unnecessarily expensive. Specifications for finish hardware shall be reviewed with the University Architect, the using agency, and Facilities Operations and Development's Lock & Key Services prior to completion of construction documents. Make submittal at a time that will allow for adequate review and for making required changes before final printing.
- .5 STANDARDS AND APPROVED EQUALS: For each item, specify and schedule products of one manufacturer as the standard and, whenever possible, name two other manufacturers whose products are PROVEN equal.
- .5.1 A complete list of items proposed as the standards, together with manufacturers' names and with the names of manufacturers whose products are proposed as equals must be included in the outline specifications for the Basic Submittal. Approval of the items must be obtained before their inclusion in the hardware schedule in final documents.
- .6 REMOVABLE MULLIONS: A minimum of one pair of exterior double doors shall have a keyed, removable mullion with lock strike unless approval is given by the University Architect to deviate from this requirement. The keyed removable mullion shall accept the approved cylinders per section 08 71 90.4, also see 08 00 20.
- .7 A COORDINATION MEETING for the electrical contractor and the hardware supplier is required prior to the creation of shop drawings on projects that require card readers or similar electronic access devices.
- 08 71 00. FINISH HARDWARE WARRANTY
- A. Manufacturer's Warranty:
1. Closers: Ten years
  2. Exit Devices: Three years
  3. Mortise locksets & Cylinders: Three years
  4. All other Hardware: Two years
- 08 71 10. BUTTS: Five-knuckle, wrought-steel. Specify ball bearing butts for doors equipped with closers. Butts shall be heavy duty, with 4 bb for exterior doors and interior doors over 3 feet wide; use standard weight butts with 2 bb for interior doors up to 3 feet wide. Specify non-bb for all doors without closers.
- .1 STAINLESS STEEL BUTTS must be used on exterior doors. Continuous stainless steel hinges may also be used, except at security/electrified doors.
- 08 71 20. LOCKS: Locksets and latchsets shall be heavy duty mortise type with hinged, anti-friction, ¾ inch throw latchbolt with anti-friction piece made of self lubricating stainless steel. Deadbolt function shall be 1-inch projection with two hardened steel roll pins. All locksets and latchsets must conform to ANSI A156.13, Series 1000, Operational Grade 1 and Security Grade 2 and be listed by UL. All locksets are to be supplied by the same manufacturer.
- OARDC: OARDC requires mortise locksets on exterior and higher security doors and will permit cylinder locksets with integral cores in accepted interior locations. Consult with the Project Manager and OARDC for the acceptable locations.**
- .1 FUNCTIONS: Unless instructed otherwise by the University Architect, select locksets and latchsets having the following functions. Specifications or door schedules shall

**DIVISION 08 –OPENINGS**

---

show both the Building Hardware Manufacturers Association (BHMA) and the manufacturer's numbers to aid checking of documents and reduce the opportunity for error in function.

Door Location or Usage	BHMA No.	Function
.1.1 High Security outside outside and and	F12	Latch bolt by lever either side unless lever locked by stop button; when lever locked, latch bolt by key outside lever inside; dead bolt by key outside turnpiece inside; continuous turn of key retracts both latch and dead bolt.
.1.2 Normal Office outside outside and latch	F04	Latch bolt by lever either side unless lever locked by stop button; when lever locked, latch bolt by key outside lever inside; auxiliary latch deadlocks bolt.
.1.3 Private Office Door, Mechanical deadlocks	F07	Latch by lever inside and key Equipment outside; outside lever rigid; Rooms, Storage auxiliary latch Closets latch bolt.
.1.4 Classroom Door outside lever locked, inside;	F05	Latch bolt by lever either side unless lever is locked by key outside; inside always free; when outside lever is latch bolt by key outside and lever auxiliary latch deadlocks latch bolt.
.1.5 Communicating Doors	F01	Latch bolt by lever either side.
.1.6 Pipe Chase retract	*	*Classroom Function Deadbolt By key outside; turnpiece inside will dead bolt but will not project it; no levers.
.1.7 Outside Entrance Door	**	** Verify function with FOD Lock & Key Services; Outside by key only; pull handle outside with no thumb piece; panic bar with dogging by keyed cylinder; latch bolt, no vertical rod.
.1.8 Bath/Privacy inside access	F22	Latchbolt retracted by lever - from either side unless outside is locked by turn piece. Operating inside lever- or closing door unlocks lever-. To unlock from outside, remove emergency button, insert emergency turn (furnished) in hole and rotate.
.1.9 Lever Handles shall be wrought brass, bronze or stainless steel of simple design, heavy duty, and must have inside lever handle secured in place by a dowel screw and the outside lever handle (secure side) pinned to the spindle.		
.1.10 Acceptable lever lock sets are:		
Manufacturer	Series	Lever Style

**DIVISION 08 – OPENINGS**

---

Best Access Systems	35H	15J or 3J
Schlage	L9000	06N or 03N
Marshall Best	RW	S or T

Best 35H Series is available only to Ohio State University. No substitutions/No equals.

08 71 30. CLOSERS: Acceptable closers are: No substitutions/No equals

LCN	4000 series,
Stanley	D4550 series,
Sargent	421 series

Closers shall be surface mounted, with full rack and pinion hydraulic action. Specify very heavy-duty type with broad range of adjustments permitting adjustment of door. Open pressure of 8 pounds to 15 pounds. Covers shall be of clean line design with lacquer finish and shall be type that DOES REQUIRE removal to make adjustments.

.1 INSTALLATION: Closers for interior doors shall be installed on room side of doors and shall not be visible from corridors, lobbies, and other public spaces.

.2 Acceptable NON-ELECTRIFIED exit devices are: No substitutes/No equals.

Manufacturer	Series	Trim
Von Duprin	98/99 rim type 9927 LBR only (see 08 70 20.6)	Exterior – 990 DT or NL Interior – 996L (06 or 03 lever)
Precision	<u>Apex</u> 2000 rim type	Exterior – 1703A or 1702A Interior – 4903A or 4908A

08 71 50. STOPS: Wall mounted convex rubber bumpers, with concealed fasteners. Provide noncombustible blocking in wall as required for bumper installation

.1 OVERHEAD STOPS AND HOLDERS: Size as recommended by the manufacturer. Degree of opening, as determined by building conditions. Stops required on all exterior doors.

08 71 60. FLUSH BOLTS: Specify extension type, top and bottom; avoid the use of vertical bars, either concealed or exposed. Minimum ½-inch diameter rods of, brass, bronze, or stainless steel with minimum 12-inch long rod for doors up to 7'-0" in height. Provide 1-inch minimum throw for all dead bolts. Auto flush bolts to be used only with approval of Facilities Operations and Development's Lock & Key Services. Not to be used on the centrally supported Alarm and Card Access Management Systems (ACAMS) monitored doors.

08 71 70. KICK PLATES: Plastic laminate, stainless steel and bronze kick plates are acceptable for wood doors. Omit on steel and aluminum doors.

08 71 80. FINISHES: Closers shall be finished to suit room décor. For all other hardware, specify US-10 or US-26D. Other finishes may be used only where necessary to match materials to which hardware is applied.

08 71 90. KEYING: Include the following paragraph in the specifications:

.1 LOCKING DEVICES shall be equipped with approved cylinders per 08 71 90.3 and 08 71 90.4 and accept Stanley Security Solutions small format 7-pin interchangeable core. For security while the building is under construction the exterior doors locks

shall be equipped with temporary keyed brass construction cores furnished and installed by the General Contractor. The GC is to provide (5) five master keys and one change key for the construction cores to be delivered to FOD's Lock and Key Services through the University's Project Manager. The GC shall install the disposable black plastic construction cores that come with the locks, as the interior door locking devices are installed. Following approval by Facilities Operations and Development's (FOD's) Lock & Key Services and the Using Agency of the final keying schedule, Stanley Security Solutions will combine permanent cores, cut, and tag one key per core and deliver cores and keys directly to FOD's Lock & Key Services for installation by FOD's Lock & Key Services in exchange for temporary cores removed by FOD's Lock & Key Services and returned to the General Contractor.

.1.1 For Regional Campus projects: Locking Devices shall be equipped and keyed as stated in 08 71 90.1 with the following revisions:

- a. The temporary keys are to be delivered to the Regional Campus through the Project Manager.
- b. Following approval by the Regional Campus with consultation with Facilities Operations and Development's (FOD's) Lock & Key Services and the Using Agency of the final keying schedule, Stanley Security Solutions will combine permanent cores, cut, and tag one key per core and deliver cores and keys directly to the Regional Campus for installation by the Regional Campus in exchange for temporary cores removed by the Regional Campus and returned to the General Contractor. The cost for cores and keys is the responsibility of the General Contractor.

**Commentary:** *Regional Campus consultation with Facilities Operations and Development's Lock & Key Services is for the purpose of maintaining a central data base for keying and provide general support to the Regional Campuses.*

c. **OARDC:** Interchangeable cores for OARDC projects are to be BEST, 6-pin, "A" keyway by Stanley Security Solutions. No Substitutions.

d. **OARDC:** Master and change (core) keys for OARDC projects are to be delivered as un-cut key blanks directly to OARDC Facilities Services.

.2 The Architect/Engineer (A/E) shall place in the specification that the Hardware Contractor shall enter into an agreement with Facilities Operations and Development's (FOD's) Lock & Key Services to install the final cores during the construction period. Provide an allowance for this work after consulting with FOD's Lock & Key Services for current/projected charges per core (approximately 1/10 hour per core at the University's current Skilled Craft Rate).

.2.1 For Regional Campus projects the Architect / Engineer (A/E) shall place in the specification that the Hardware Contractor shall enter into an agreement with the Regional Campus to install the final cores during the construction period. Provide an allowance for this work after consulting with the Regional Campus



## DIVISION 08 –OPENINGS

---

for current/ projected charges per core (approximately 1/10 hour per core at the University's current Skilled Craft Rate).

**OARDC:** Final cores installed for OARDC projects will be installed at no cost by OARDC's Facilities Services.

.3 CYLINDERS FOR MISCELLANEOUS LOCKS: Approved cylinders per 08 71 90.4 shall accept Stanley Security Solutions small format 7-pin interchangeable core.

.4 Approved cylinders are: No substitutions/No equals

Stanley Security Solutions	1E7 Series
Arrow	16CR
Falcon	C Series
Marshall Best	MBS-IC (M or R) 726D

### 08 72 00. POWER DOOR OPERATORS

.1 POWER DOOR OPERATORS providing access for individuals with disabilities may be surface mounted. Concealed operators are not permitted. All operator switches providing access for individuals with disabilities shall be 6 inches in diameter with the handicapped logo.

.2 ELECTRIC OPERATOR SWITCHES may be wall-mounted or post-mounted, and are required to be wired to the door operator. Wireless switches are not permitted.

.3 INSTALLATION AND EQUIPMENT shall be provided by a manufacturer's authorized and trained distributor. Final connection between equipment and the wiring system to be made by or under the direct supervision of the manufacturer's authorized and trained distributor.

.4 OPERATOR SYSTEM - As approved by Facilities Operations and Development's ADA Coordinator.

.5 MAINTENANCE MANUALS in triplicate shall be provided to Facilities Operations and Development showing templates, wiring diagrams and full maintenance instructions.

.6 AUTOMATIC RESET is required. If the door is locked or if door encounters an obstacle when the operator is activated, the operator system will do one of the following:

.6.1 Continue to push gently on the door until the time delay period expires, then close.

.6.2 Sense the resistance, shut off power and close.

.7 OPERATOR SYSTEMS shall have:

.7.1 Adjustable time delay period (opening time plus hold-open time) shall be approximately 20 seconds, adjustable from at least 40 seconds to 7 seconds minimum.

.7.2 Adjustable opening speed (time from activation until door is fully open) shall be approximately 7 seconds, adjustable from at least 11 seconds to 5 seconds minimum.

.7.3 Slow closing speed of approximately 7 seconds. Adjustability is desirable but not mandatory.

## DIVISION 08 – OPENINGS

---

- .7.4 Full compliance with ANSI/BHMA A156.10 and Ohio Building Code.
  - .7.5 Weatherproof controls and circuitry.
  - .7.6 Low voltage current from operators to controls.
  - .7.7 Heavy-uty "supermrket" quality.
  - .7.8 Easy manual door operation. In event of power failure or pedestrian impatience, pressure on strike side of door equal to that required to open a conventional 36" wide door with closer shall be adequate to open the door manually. Maximum of 15lbs. Opening pressure.
  - .7.9 Easy access for maintenance. Access covers, if provided, must also have vandal resistant screw attachment.
  - .7.10 Operation must be smooth and quiet.
  - .7.11 Closer shall be spring type which functions with power on or off.
  - .7.12 Approved Power Door Operators are: No substitutions/No Equals
    - LCN 4600 Series and 9500 Series
    - Gyro Tech GT710 Series
    - Stanley D4990 Series
- The Architect/Engineer (A/E) shall review the manufacturer's door weight limits.
- 08 73 00. PROVISIONS FOR NOISE CONTROL: Refer to PART ONE and to the Program of Requirements for possible special requirements. On machine room doors and other doors where excessive noise is anticipated, weatherstripping at heads and jambs and surface applied automatic door bottoms shall be specified.
- 08 74 00. ACCESS CONTROL and ALARM MONITORING SYSTEM (ACAMS) – Doors, Frames and Hardware
- .1 All card reader and/or electrically unlocked or monitored doors shall be equipped with Request to Exit functions and latchbolt monitoring integral to the door hardware. Door position switches required for each door.
  - .2 Card reader and/or electrically unlocked doors shall be operated as pairs where applicable.
  - .3 Wiring in door frames shall be in conduit from the transfer hinge location to a junction box external to the frame for connection to the Access Control and Alarm Monitoring System (ACAMS).
  - .4 Hardware equipped with a cylinder/core shall be installed such that the key retracts the latch only and the key action will not permit the door hardware to remain in an unlocked condition.
  - .5 Doors with electrified exit devices shall utilize Von Duprin EPT- 10 power transfer hinges. No substitutions/No equals.
  - .6 All hardware under this section to be installed per manufacturers specifications. Failure to follow specifications will result in door hardware and security system

## DIVISION 08 –OPENINGS

---

malfunctions. Door hardware, electrical, and security contractors shall coordinate the installation and adjustment of door hardware components to perform as part of an integrated Access Control and Alarm Monitoring System.

- .7 DOOR APPLICATION / HARDWARE REQUIREMENTS Access Control and Alarm Monitoring System (ACAMS) Doors
  - .7.1 Exterior Doors with exit devices: Exit devices shall be equipped with electric latch retract, cylinder dogging, pull handle (no thumb latch), request to exit, fully adjustable latchbolt monitoring, door position switches.
  - .7.2 Interior Doors with exit devices: Exit devices shall be equipped with electric latch retract or electrically unlocking (fail secure) lever trim, request to exit, fully adjustable latchbolt monitoring, door position switches.
  - .7.3 Fire Exit Doors: Fire Exit - doors with exit devices-fail safe electric trim with request to exit, fully adjustable latchbolt monitoring, and door position switches.
  - .7.4 Fire exit doors with mortise lock-fail safe, (Temperature control module where required by manufacturer) request to exit, latchbolt monitoring, door position switches.
  - .7.5 Mortise Lock Doors: Fail Secure, request to exit, latchbolt monitoring, door position switches.
  - .7.6 Power Transfer Hinges: Exit Devices - Von Duprin EPT-10, No substitutions/No equals. Mortise Locks - wired ball bearing transfer hinges.
  - .7.7 Delayed Egress Devices: Von Duprin 99 Series Chexit devices, No substitutions / No equals. Interior doors - Lever trim. Exterior doors - Exit only function.
  - .7.8 Power Supplies: Per manufacturer's specifications.
  - .7.9 Auto opener/card reader operated door: Access system shall enable outside button upon authorized card swipe as determined by the Access Control and Alarm Monitoring System (ACAMS). A successful card swipe shall not automatically energize the automatic opener. The interior button shall remain active at all times and provide a request to exit signal to the ACAMS system as well as initiate the auto opener. There shall be a delay in the auto opener activation such that the door hardware latches are retracted fully before the auto opener begins the door open cycle.
  - .7.10 Prohibited Hardware
    - .7.10.1 No Vertical Rod hardware to be utilized on any Access Control and Alarm Monitoring System (ACAMS) operated or monitored door.
    - .7.10.2 No electric strikes.
    - .7.10.3 No magnetic locks.
    - .7.10.4 No PIR request to exit.
- .8 ELECTRICALLY LOCKING / UNLOCKING DOOR HARDWARE- ACCESS CONTROL and ALARM MONITORING SYSTEM (ACAMS)
  - .8.1 Approved exit devices with integrated request to exit, and fully adjustable latchbolt monitoring switches: No substitutions/No equals

## DIVISION 08 – OPENINGS

---

Von Duprin RXLXEL99L-NL rim exit device (latch retract)  
Von Duprin RXLXE99L-NL rim exit device (electric trim)

- .8.2 Approved delayed egress exit devices – Von Duprin CX99 Chexit.  
No substitution/No equals.

The door position switch is to be wired to the device, and the device alarm output connected to the Alarm and Card Access Management System (ACAMS).

- .8.3 Approved mortise locks without integrated card reader,  
No substitutions/No equals.

Best 35HW7EWEU(15 or 3)J626IDHLS  
Best 35HW7EWEL(15 or 3)J626IDHLS  
Schlage XL12-245 L9080EU with Latch Monitoring  
Schlage XL12-246 L9080EL with Latch Monitoring  
(15 or 3) above denotes lever style  
BEST 35H Series is available only to Ohio State University.  
No substitutions / No equals.

- 8.4 Approved mortise locks with integrated card reader,  
No substitutions / No equals.

Best 35HW7EEU(15 or 3)MS626 IDH MAX  
Best 35HW7EEL(15 or 3)MS626 IDH MAX  
(15 or 3) above denotes lever style  
BEST 35H Series is available only to Ohio State University.  
No substitutions/No equals.

### 08 75 00 BATTERY POWERED STAND-ALONE LOCKS

- ..1 Approved Exit Device Card Reader  
Best B.A.S.I.S. V EX Trim Series Dual Validation (15 or 3 lever style)  
Part number varies based on exit device manufacturer  
No substitutions / No equals

- .2 Approved Mortise Lock Keypad  
Best EZ Series Keypad 35HZ7EV15(or 03) KPSTK626 (Keypad w/ 15 or 3 lever style)  
No substitutions / No equals

- .3 Approved Exit Device Keypad  
Best EZ Exit Hardware Trim  
Part number varies based on exit device manufacturer (15 or 3 lever style)  
No substitutions / No equals

### 08 80 00. GLAZING

- 08 80 10. DESIGN FOR ENERGY CONSERVATION: Refer to PART ONE, paragraph 00030.  
08 80 14. WIRED GLASS: Wired glass is not allowed. Substitute InfernoLite FRP 200 and 400 by Globe Amerada, PyroEdge and Pyrobel by Interedge Technologies, SuperLite I and SuperLite I-XL by SAFTI Division of O'Keefe's Inc. and FireLite and Pilkington Pyrostop by Technical Glass Products.

- 08 80 22. LAMINATED FULLY TEMPERED GLASS: Glass for exterior aluminum and stainless steel doors shall be 1/4 inch thick laminated fully tempered glass insulated units.

- .1 LAMINATED FULLY TEMPERED GLASS: Glass for interior doors with vision panels and all sidelights shall be ¼-inch thick laminated fully tempered glass.

## DIVISION 08 –OPENINGS

---

- .2 LAMINATED FULLY TEMPERED GLASS: Glass for guardrails and balusters shall be ½-inch thick laminated fully tempered glass.
- 08 82 30. INSULATING GLASS: The following paragraph shall be included in the specifications; edit the heading to apply to the particular type of glass specified.
- .1 INSULATING AND REFLECTIVE INSULATING GLASS, GUARANTEE: Provide manufacturer's written guarantee that, for ten years from date of building completion, a replacement will be provided for any unit which develops edge separation or other defects which materially obstruct vision through the glass or safety or affects the insulating qualities; except, that guarantee shall not cover glass breakage from physical abuse, earthquake, storm, or similar causes.
- .2 PARTIAL SHADING OF INSULATING GLASS can cause stress breakage. Manufacturers consider this to be a design error and will not replace glass broken by temperature differential stresses. Avoid partial shading of large panes.
- 08 83 00. MIRROR GLASS: Framed mirrors for toilet and shower rooms should be included in Division 10. Large mirrors unframed, or in custom made frames, should be included in this division.

END OF DIVISION 08 - OPENINGS

## **DIVISION 09 – FINISHES**

2006 Edition, Published January 1, 2006; Division Revision Date: February 28, 2013

### **09 00 00. FINISHES**

#### **09 00 03. GENERAL PROVISIONS**

.1 DESIGNS: All materials, colors, finishes, product specifications, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

All materials shall meet or exceed the Ohio Building Code (OBC) and University use requirements for the area.

In remodeled areas, all material patches shall blend as close as possible. Complementary colors and patterns are to match the existing materials so they do not appear patched. Testing is required for asbestos and lead paint in older finishes of a suspect nature. This is important whenever surfaces are to be patched and repaired.

.2 LEED POLICIES: The University promotes energy efficient green design, construction and building operations. Whenever possible, materials are to be selected and specified following the United States Green Building Council LEED (Leadership in Energy and Environmental Design) Green Building Rating System® consensus-based national standard for developing high-performance, sustainable buildings. Refer to the website: <http://www.usgbc.org/>.

#### **09 01 00. MAINTENANCE OF FINISHES**

.1 DESIGNS: The Associate shall specify only finishes that require little maintenance and can be easily maintained by the University.

#### **09 06 00. SCHEDULES FOR FINISHES**

.1 DESIGNS: The Associate shall clearly note all finishes and their extent of coverage on the drawings and specifications using room finish schedules and include notations on elevations and details.

#### **09 06 90. SCHEDULES FOR PAINTING AND COATING**

1. COATINGS SCHEDULE: The Associate shall prepare a schedule listing all surfaces in generic terms, all coating or finish operations, the types of finish materials and the number of coats of each material.

#### **09 08 00. COMMISSIONING OF FINISHES**

.1 RESILIENT FLOORING: Immediately prior to final inspection, resilient flooring and base shall be cleaned as per the manufacturer's recommended guidelines and ready for final finishes. The Contractor shall finish the floor using the manufacturers or University provided waxes.

.2 CARPETS: Immediately prior to FF&E installation, all carpeted areas shall be cleaned and vacuumed of all construction debris and made ready for installation of FF&E. The Contractor shall clean and vacuum.

## **DIVISION 09 - FINISHES**

---

### **09 20 00. PLASTER AND GYPSUM BOARD**

#### **09 21 13. PLASTER ASSEMBLIES**

- .1 DESIGNS: The use of plaster for ceilings and of stucco for exterior finish, including canopy soffits, is prohibited without written permission of the University Architect; however, these materials may be used for patching existing plastered surfaces. The Associate may request permission to use these materials in limited areas, only if the situation is unique and architecturally demanding.

#### **09 21 16. GYPSUM BOARD ASSEMBLIES**

- .1 DESIGNS: For sound control requirements, refer to PART ONE, paragraph 00035.

### **09 30 00. TILING**

- .1 DESIGNS: Ceramic floor and wall tile or other suitable solid surface material approved by the University Architect, is required for all restrooms, shower rooms, food preparation, food serving and other common areas where water and food is present.

All floor tiles shall be non-slip and rated for heavy duty use.

For designs where floor and wall tile indicate a pattern of colors, details shall be clearly detailed on the Construction Drawings using specific tile sizes, dimensions and details of all surfaces to receive tile.

Designs of ceramic "mosaics" shall include specific tile sizes and detailed drawings showing extent or complexity of patterns.

All floor tile grout shall be sealed. In frequently wet areas such as shower and pools areas, floor and wall grout shall be sealed.

### **09 50 00. CEILINGS**

- .1 DESIGNS: All ceilings shall be designed to be easily accessible for maintenance and other access needs such as technology installations. A single type of ceiling tile, tile size and suspension system shall be used throughout a building to minimize maintenance and repair costs. Limited exceptions to this are special feature areas or specialized function areas where no accessibility is required. The use of 3 foot tile and other non standard tile sizes is prohibited.

Fire code gypsum board or fire rated acoustic tile with rated suspension assembly shall be used for fire-rated ceilings.

### **09 51 00. ACOUSTICAL CEILINGS**

- .1 DESIGNS: Mineral fiber lay-in type acoustic ceilings shall be specified. Panels shall be a minimum of 5/8 inch thick and maximum panel size shall be 2 ft. x 4 ft or 2 ft x 2 ft. A single type and size of acoustic ceiling panel shall be consistent throughout a building for maintenance purposes.

Other size panel sizes and materials proposed are subject to review and approval by the University Architect.

## **DIVISION 09 - FINISHES**

---

For design requirements relative to sound control, refer to PART ONE, paragraph 00035.

### **09 53 00. ACOUSTICAL CEILING SUSPENSION ASSEMBLIES**

- .1 **DESIGNS:** Ceiling suspension assemblies shall be supported directly from the building structure and shall be supported at all four corners of fluorescent light fixtures. Ceilings shall not be supported from ductwork, electrical conduit, heating or plumbing lines, and vice versa. Each utility system and the ceiling grid system shall be a separate installation and each shall be independently supported from the building structure. Where interferences occur, provide trapeze type hangers or other suitable supports for each system. Locate hangers and supports where they will not interfere with access to mixing boxes, fire dampers, valves, and other appurtenances requiring servicing.

The requirements for independent supports for ceiling grid systems shall be repeated in the applicable sections of the specifications. If patented ceiling suspension systems are required for plaster, gypsum board, and acoustic ceilings, a separate section may be written for the systems; or each separate system may be specified in the section for the particular ceiling material, at the option of the Associate; however, it is preferred that suspension systems for acoustic ceilings be specified with the ceiling materials to avoid divided responsibilities.

Stainless steel hanger wires must be specified for canopy suspension systems and for other systems in locations subject to moisture penetration or condensation

- .2 **ANCHORAGES:** Power-driven anchors are prohibited and shall be noted in the specifications. Ceiling suspension systems shall be secured to the structure with toggle, molly bolts, self-drilling anchors, cast-in inserts, or bolts in expansion shields. The use of wood, lead, or plastic plug anchors is also prohibited.

### **09 60 00. FLOORING**

- .1 **DESIGNS:** Associate selections shall be based on extra heavy duty commercial grade flooring, rated for intended use by the manufacturer. Custom materials and colorations are prohibited as they increase later costs for repair and renovations. Specify designs for visually impaired where applicable. Specify designs for static dissipation requirements where applicable.

All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

In some cases, the University may choose to purchase Flooring for a project. In these cases, the cost of Flooring is moved from Construction funds to Equipment funds for the purchase. Design of spaces, door clearances and scheduling of the work where Flooring is required must provide for these installations, whether Flooring is provided by the Contractor or by the University.

The Associate shall provide detailed specifications of at least one selected product and two additional products which are acceptable equals in material construction and color for bidding.

The Associate shall specify products that can be obtained and installed by Contractors of an established firm, experienced in the installation of the specified product. The specifications shall request Contractors to have completed at least three projects of equal size, material and complexity to verify experience.



## **DIVISION 09 - FINISHES**

---

- .2        **INSTALLATION CONDITIONS:** The Associate shall specify critical Flooring Substrate Conditions appropriate to the material specified. The Associate shall include standard testing methods for determining Relative Humidity in concrete flooring, Moisture Vapor Emission Rate of concrete subfloor. The Associate shall outline Contractor responsibility for conducting the tests prior to installation.

### **09 65 00. RESILIENT FLOORING**

#### **09 65 13. RESILIENT BASE AND ACCESSORIES**

##### **09 65 13.13 RESILIENT BASE**

- .1        **MATERIALS:** Base to be 1/8 inch thick, rounded top edge and 4-inch minimum height. Specify straight wall base for carpeted areas and coved wall base with toe for resilient flooring areas. Specify that internal and external corners be formed on the job with joints at 18-inches from corners. Terminal ends of base shall be beveled and toes rounded. Color to be integrated with the material. Material can be vinyl or rubber.

- .2        **WARRANTIES:** Meet or exceed 5 year material warranty.

##### **09 65 13.23 RESILIENT STAIR TREADS AND RISERS**

- .1        **MATERIALS:** Color integrated treads and risers, vinyl or rubber. Slip resistant and easily maintainable.

- .2        **WARRANTIES:** Meet or exceed 5 years material warranty.

##### **09 65 16. RESILIENT SHEET FLOORING**

- .1        **MATERIALS:** Commercial grade, high performance homogeneous sheet flooring. Seams to be heat welded, when possible. Use standard 4 inch high cove base at wall. A 6 inch high flash coving may be specified to enhance hygienic qualities. Where applicable, manufacturers to provide stain resistance test data, coefficient of friction ratings (wet and dry), load bearing capacity and other standardized test data as may apply.

Overall Nominal Thickness: .080 inches

Reference Specs: Meets or exceeds ASTM F-1913; Type II, Grade 1

Fire Test Data: Meets ASTM E-648 (Critical Radiant Flux) / ASTM E-662 (Smoke Density)

Static Load Limit: ASTM F-970 250 PSI (Std.), 700 PSI

Slip-Retardant Performance: ASTM D-2047 James Test; Exceeds ADA recommendation.

Traffic Performance: Rated for extra heavy commercial traffic.

Recycled Vinyl Content to be 10% or greater.

- .2        **WARRANTIES:** Meet or exceed 5 years material warranty.

## **DIVISION 09 - FINISHES**

---

### 09 65 16.13 LINOLEUM FLOORING

- .1 MATERIALS (SHEET): Homogeneous linoleum sheet floor covering made of primarily natural materials consisting of linseed oil, wood flour, rosin binders and dry pigments mixed and calendared using a two-layered process onto a jute backing including a strong, durable primer and a top layer. Seams to be heat welded.

Reference Specs: Meets or exceeds ASTM F2034 for Linoleum Sheet Flooring.

Overall nominal thickness: .100 inches.

Static Load Limit: 450 pounds per square inch.

Traffic Performance: Rated for extra heavy commercial traffic.

Recycled content: 45% or greater Post Industrial Recycled Content.

- .2 MATERIALS (TILE): Homogeneous linoleum tile floor covering shall be made of primarily natural materials consisting of linseed oil wood flour, rosin binders and dry pigments mixed and calendared using a two-layered process) onto a polyester back . Standard sizes no customs.

Reference Specs: Meets or exceeds ASTM F2195 for Linoleum Tile

Static Load Limit 1500 pounds per square inch

Traffic Performance: Rated for extra heavy commercial traffic.

Recycled content: 45% or greater Post Industrial Recycled Content.

- .3 WARRANTIES: Meet or exceed 5 years material warranty.

### 09 65 19. RESILIENT TILE FLOORING

- .1 MATERIALS: Vinyl Composition Tile, 1/8 inch thick, thru-pattern or thru-chip construction and meets the requirements of the ADA for static coefficient of friction when installed in accordance with manufacturer's guidelines, waxes and coatings. Recycle content (post-consumer and post-industrial waste) minimum 10%. Resilient tile is prohibited next to urinals. Specify standard tile sizes.

Static load limit: 75 PSI

Flooring Radiant Panel Test: Passes

Flame Spread: Passes

The Associate may propose resilient materials other than vinyl composition tile that are advantageous to the project. Approval of the University Architect is required prior to specifying such materials.

Acceptable material quality: equal or better than Armstrong Excelon Vinyl Composition Tile.

- .2 WARRANTIES: Meet or exceed 5 years material warranty.

### **09 66 00. TERRAZZO FLOORING**

- .1 MATERIALS: Terrazzo floors separated from the structural slab by a sand cushion are preferred. Approximately 2-3/4 inches shall be allowed from rough slab to finish floor.

## **DIVISION 09 - FINISHES**

---

### **09 66 23. RESINOUS MATRIX TERRAZZO FLOORING**

- .1 **DESIGNS:** If design conditions, or budget, dictate thinset method of installation, marble chip or ceramic granule toppings may be installed with chemical matrix or with cement matrix chemically bonded to the substrate, only when such methods and materials are approved by the University Architect.

### **09 68 00. CARPETING**

- .1 **MATERIALS:** Acceptable material quality: equal or better than Dupont Antron Legacy nylon and Antron Lumena nylon.

Yarn: 100% first quality, bulk continuous filament nylon type 6, 6 offering a construction and performance standards testing program by fiber producer. The fiber shape to have a maximum Modification Ratio of 1.5 for soil release capabilities. The fiber identification is to AATCC 20. Static Control: By permanent means (i.e. antistatic filaments) and without chemical treatment, static generation below 3.5 kilovolts under standard conditions of 65 F and 20% relative humidity. Electrostatic Propensity (Static delayed signal): AATCC 134.

Construction: tufted or woven, level or multi-level loop pile with maximum height variation of 1/32 inch.

Dye Method: Meets or exceeds Stain Resistance specification with greater than 5 years on the floor performance history.

Pile Weight: minimum 24 oz/yd<sup>2</sup>

Primary Backing: polypropylene or non-woven

Secondary Backing: to provide permanent moisture barrier

Resistance to Delamination: ASTM D3936 minimum 3.0 lbs/inch

Tuft Bind: ASTM D1335 minimum 20 lbs

Pile density 36 x face weight/finished pile HEIGHT: minimum 5800

Flammability – Must pass Methenamine Pill test (DOC FF1-70). Meet Flooring Radiant Panel Test – Class 1. NBS Smoke Chamber – must meet or exceed 350 or less in flaming mode.

Colorfastness to Light: AATCC 16E, 200 AFU, International Gray Scale for Color Change rating min 3-4.

Colorfastness to atmospheric contaminants: AATCC 164(ozone) & AATCC 129 (oxides of nitrogen) for 2 cycles, International Gray Scale for Color Change rating min. 3-4.

Stain Resistance - AATCC 138 for 5 washings to simulate removal of topical treatments by hot water extraction, followed by: AATCC 175, minimum level 8 using AATCC Red Dye 40 Scale with greater than 5 years on the floor performance history.

Soil Resistance: An average of 3 fluorine analyses (AATCC 189) of a single composite sample to be a minimum of 500 ppm fluorine by weight when new and 400 ppm fluorine by weight after 2 AATCC 171 (HWE) cleanings.

## **DIVISION 09 - FINISHES**

---

Coloration: Color hue and values to be in optimum light reflectance rating for soil hiding enhancement.

Appearance Retention - Vetterman Drum Test ASTM D5417 for 22,000 cycles. This is a minimum rating of 3.0 using CRI TM-101 Reference Scale. Testing without underpad or brushing.

Indoor Air Quality - maximum 0.5 mg/m<sup>2</sup>hr total VOC emission, ASTM D5116  
Warranty: Must meet or exceed 10 year warranty.

.2 SUBMITTALS: Specify shop drawing submittals with seam layouts for approval. Specify sample materials submittal for approval.

.3 INSTALLATIONS: In normal installations, carpet shall be glued to the substrate with no cushion or pad using premium quality waterproof non-flammable adhesive.

For exceptional instances requiring carpet installation over padding, the cushion or pad shall be factory applied and an integral part of the product. Use high density sponge rubber carpet cushion equal to or better than Tred-Mor flat profile carpet cushion as manufactured by SCI (Sponge-Cushion, Inc.) with minimum specifications for extra heavy commercial and institutional traffic.

.4 RECLAMATION: Designate Reclamation Program or agency firm providing used carpet recycling. Reclamation agency and carpet remover shall certify in writing that used carpet was removed and recycled in accordance with Reclamation Program.

Adhesive removal Solvents must comply with Carpet and Rug Institute Publication 104.

### **09 70 00. WALL FINISHES**

.1 DESIGNS: Associate selections shall be based on extra heavy duty commercial wall finish, rated for intended use by the manufacturer. Custom materials and colorations are prohibited as they increase later costs for repair and renovations.

All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

The Associate shall provide detailed specifications of at least one selected product and two additional products which are acceptable equals in material construction and color for bidding.

The Associate shall specify products that can be obtained and installed by Contractors of an established firm, experienced in the installation of the specified product. The specifications shall request Contractors to have completed at least three projects of equal size, material and complexity to verify experience.

### **09 72 00. WALL COVERINGS**

.1 MATERIALS: Materials must conform to ASTM E-84 and OBC. Research code carefully to determine class of fire and smoke resistance required for the specific application.

Vinyl wall covering must satisfactorily pass Class A physical requirements for Type II wall covering as listed in G.S.A. CCC-W-408A and CFFA Quality Standards for vinyl coated fabric wall covering.

## DIVISION 09 - FINISHES

---

### 09 90 00. PAINTING AND COATING

#### 09 91 23. INTERIOR PAINTING

##### .1 APPLICATIONS:

TOP AND BOTTOM EDGES OF WOOD DOORS shall be sealed after fitting and finished with at least two coats of varnish or paint.

TOPS AND BOTTOMS OF METAL DOORS shall be painted with the same materials and number of coats as used on the door faces.

DRY FILM THICKNESSES shall be specified for all coats of paint on metals.

ACCENT COLORS: If it is anticipated 5% or more of the scheduled finishes will be in accent colors, attention should be called to this fact. Estimated percentage of accent colors should be given as an aid to bidders in preparation of bids. A statement should be made to the effect that the information given in no way restricts the Associate in his final selection of colors.

COLOR CODING FOR PIPING: Include finish painting of insulated and uninsulated piping in the General Construction Documents and include color banding of finished piping in the appropriate locations. See Divisions in the Facilities Services Subgroup.

INTERIOR WOODWORK: Painted finish -- primer and 2 coats semi-gloss alkyd enamel.

METAL DOORS AND FRAMES: Shop coat, touch up and two coats semi-gloss enamel.

NEW GYPSUM WALLBOARD OR PLASTER: Spackle as required, primer and 2 coats semi-gloss alkyd enamel or 2 coats semi-gloss latex.

EXISTING PREVIOUSLY PAINTED GYPSUM WALLBOARD OR PLASTER: Primer and 1 coat semi-gloss alkyd enamel or semi-gloss latex. If surface is poor, remove finish to substrate, repair and finish the same as new gypsum wallboard or plaster.

INTERIOR CONCRETE OR CONCRETE BLOCK (Unpainted): 1 coat self-sealing heavy filler-type primer and 2 coats semi-gloss alkyd enamel or 2 coats semi-gloss latex. For laboratories requiring chemical resistance, replace the alkyd or latex paint with epoxy two-component finish. For corridors or abuse areas, replace the semi-gloss alkyd or latex paint with high gloss alkyd enamel.

All painting shall be in compliance with Master Painters Institute (MPI) standards.

Whenever possible select products having low or no VOC's or odors. Use paints having low VOC's that meet EPA and consensus industry requirements. Substitute water-based products where possible.

Provide MSDS for each product to OSU-EHS

Whenever possible and feasible, restrict painting to those times when the building is unoccupied.

Paints should be applied using appropriate techniques to reduce the amount of volatiles released into the air.

Sufficient amounts of local exhaust ventilation should be employed to keep the buildup of odors and toxic compounds within the building to a minimum.

## **DIVISION 09 - FINISHES**

---

The building occupants should be notified of the scheduled application so they are aware of the work and can make other occupancy arrangements if chemically sensitive.

### **09 93 00. STAINING AND TRANSPARENT FINISHING**

#### **.1 APPLICATIONS:**

INTERIOR WOODWORK: Natural finish -- stain, 2 coats sanding sealer, 2 coats semi-gloss varnish. If polyurethane varnish is used, delete sanding sealer.

TOP AND BOTTOM EDGES OF WOOD DOORS shall be sealed after fitting and finished with at least two coats of varnish or paint.

EXTERIOR WOOD PLATFORMS OR BENCHES: Use Behr plus 10 Solid Color Stain or approved equal in accordance with manufacturer's directions.

### **09 96 00. HIGH PERFORMANCE COATINGS**

#### **09 96 43. FIRE RETARDANT COATINGS**

.1 INSTALLATIONS: Materials shall be applied by applicators franchised and approved by manufacturers of materials approved for use. General Contractor shall furnish the manufacturer's certification that materials delivered to the project meet requirements specified. Certification shall be countersigned by the General Contractor, who shall assume the responsibility of complying with the manufacturer's specifications. Materials and application equipment shall be of type approved by the manufacturer.

#### **09 96 53. ELASTOMERIC COATINGS**

.1 INSTALLATIONS: If coatings specified can be applied with equipment ordinarily used by painters, these coatings may be specified in the section entitled, PAINTING.

### **09 97 00. SPECIAL COATINGS**

#### **09 97 23. CONCRETE AND MASONRY COATINGS**

.1 DESIGNS: Mechanical Room and other Service Room floors in all buildings shall be completely sealed from water and moisture penetration to the floors below.

---

**END OF DIVISION 09 - FINISHES**

## **DIVISION 10 - SPECIALTIES**

2006 Edition, Published January 1, 2006; Division Revision Date: February 28, 2013

### **10 00 00. SPECIALTIES**

#### **10 00 03. GENERAL PROVISIONS**

- .1 Refer to PART ONE, paragraph 00037, Fixtures, Furniture and Equipment (FF&E)
- .2 **DESIGNS:** The Associate shall provide layouts of all Specialties to determine function and space use for the project. Submittals are required as outlined in the Associate Agreement for Basic Services.
- .3 **CONSTRUCTION COORDINATION:** The Associate shall clearly define Contractor responsibilities relative to receiving, storage and installing all items in this Division. The Associate is to locate and coordinate all blocking, support and services for installation of all items in this Division.

### **10 10 00. INFORMATION SPECIALTIES**

#### **10 11 00. VISUAL DISPLAY SURFACES**

##### 10 11 13. CHALKBOARDS

- .1 **WARRANTIES:** Lifetime warranty required and shall indicate that under normal usage and maintenance, porcelain enamel steel chalkboards are guaranteed for the life of the building.
- .2 **DESIGNS:** All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents. Writing surface shall be standard black.

##### 10 11 13.13 FIXED CHALKBOARDS

- .1 **BUDGET ALLOCATIONS:** Fixed classroom and public chalkboards shall be considered Fixed Equipment and are funded within the Construction Budget.
- .2 **MATERIALS AND CONSTRUCTION:** Chalkboards shall be porcelain enamel steel and shall be manufactured in accordance with Porcelain Enamel Institute's specification. Porcelain enamel finish shall be fusion bonded to a 24 gauge steel substrate at temperature necessary to reduce steel and porcelain stresses and achieve superior enamel bond and hardness.
  - .2.1 Face Sheet: 24 gauge steel
  - .2.2 Core Material: ¼" hardboard, 7/16" MDF or 3/8" particle board
  - .2.3 Panel Backing: aluminum foil or sheet moisture barrier
  - .2.4 Laminations: hot type neoprene contact adhesive to both surfaces with minimum of 80% coverage. Laminations shall be made by face sheet manufacturer.
- .3 **TRAY:** Standard continuous, solid box type aluminum tray with ribbed section and injection molded end closures.
- .4 **MAP RAIL:** Standard continuous, 2" map rail with cork insert and end stops at the top of each board. Furnish (4) map hooks every eight feet.

## DIVISION 10 - SPECIALTIES

---

### 10 11 13.43 PORTABLE CHALKBOARDS

- .1 REQUIREMENTS: Warranty, Selection Approval, Materials and Construction same as indicated for Fixed Chalkboards.
- .2 BUDGET ALLOCATIONS: Portable Office Markerboards are considered Movable Equipment and acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction Budget.
- .3 MATERIALS AND CONSTRUCTION: Chalkboards shall match and coordinate with the design intent of the Construction Documents and Movable Equipment design. In general, they shall be porcelain enamel steel and required durability is same as for pool classroom use.

### 10 11 16. MARKERBOARDS

- .1 WARRANTIES: Lifetime warranty required and shall indicate that under normal usage and maintenance, porcelain enamel steel Markerboards are guaranteed for the life of the building.
- .2 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

### 10 11 13.13 FIXED MARKERBOARDS

- .1 BUDGET ALLOCATIONS: Fixed Classroom and public Markerboards shall be considered Fixed Equipment and are funded within the Construction Budget.
- .2 MATERIALS AND CONSTRUCTION: Markerboards shall be porcelain enamel steel and shall be manufactured in accordance with Porcelain Enamel Institute's specification. Porcelain enamel finish shall be fusion bonded to a 24 gauge steel substrate at temperature necessary to reduce steel and porcelain stresses and achieve superior enamel bond and hardness.
  - .2.1 Face Sheet: 24 gauge steel
  - .2.2 Core Material: ¼" hardboard, 7/16" MDF or 3/8" particle board
  - .2.3 Panel Backing: aluminum foil or sheet moisture barrier
  - .2.4 Laminations: hot type neoprene contact adhesive to both surfaces with minimum of 80% coverage. Laminations shall be made by face sheet manufacturer.
- .3 TRAY: Standard continuous, solid box type aluminum tray with ribbed section and injection molded end closures.
- .4 MAP RAIL: Standard continuous, 2" map rail with cork insert and end stops at the top of each board. Furnish (4) map hooks every eight feet.

### 10 11 13.43 PORTABLE MARKERBOARDS

- .1 REQUIREMENTS: Warranty, Designs, Materials and Construction same as indicated for Fixed Markerboards.



## DIVISION 10 - SPECIALTIES

---

- .2 BUDGET ALLOCATIONS: Portable Markerboards are considered Movable Equipment and acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction Budget.
- .3 MATERIALS AND CONSTRUCTION: Markerboards shall match and coordinate with the design intent of the Construction Documents and Movable Equipment design. In general, they shall be porcelain enamel steel and required durability is same as for pool classroom use.

### 10 11 16.53 ELECTRONIC MARKERBOARDS

- .1 BUDGET ALLOCATIONS: Electronic Markerboards are considered technology equipment and acquired by the University as Movable Equipment. Conduits, power, data, blocking and other support for technology however, shall be designed and funded within the Construction Budget.
- .2 CONSTRUCTION COORDINATION: Necessary power, data, blocking and other support for technology equipment shall be included in the Construction Documents.

### 10 11 23. TACKBOARDS

- .1 DESIGNS: In public corridors and lobbies, the Associate shall make provisions for tack board and display areas as required by the project. These tack boards and display areas shall be integrated into the architectural design of the building. Typically, small tack boards are located outside each classroom, office, conference room and other areas of assembly for general memos and other information. Large tack boards and displays are located in public areas. The Associate shall be alerted to coordinate room signage, donor plaques, artwork and other graphics if these are scheduled to be in the same location.  
  
All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

### 10 11 23.13 FIXED TACKBOARDS

- .1 BUDGET ALLOCATIONS: Fixed Classroom and public Tackboards are considered Fixed Equipment and are funded within the Construction Budget.
- .2 MATERIALS AND CONSTRUCTION: Tackboards shall be vinyl face, fabric faced or cork laminated to 1/2" thick mineral fiber board. Provide fabric and tackable core with flame-spread rating of 25 or less when tested according to ASTM E-84.

### 10 11 23.43 PORTABLE TACKBOARDS

- .1 BUDGET ALLOCATIONS: Portable tackboards are considered Movable Equipment and acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction Budget.
- .2 MATERIALS AND CONSTRUCTION: Tackboards shall match and coordinate with the design intent of the Construction Documents and Movable Equipment design. In general, they shall be vinyl face, fabric faced or cork laminated to 1/2" thick mineral fiber board and required durability is same as for classroom pool use. Provide fabric and tackable core with flame-spread rating of 25 or less when tested according to ASTM E-84.

## **DIVISION 10 - SPECIALTIES**

---

### 10 11 43. VISUAL DISPLAY WALL PANELS

- .1 See Demountable Partitions

### 10 12 00. DISPLAY CASES

- .1 **DESIGNS:** In public corridors and lobbies, the Associate shall make provisions for display cases as required by the project. These display areas shall be integrated into the architectural design of the building.

All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

- .2 **BUDGET ALLOCATIONS:** Built in Display Cases are considered Fixed Equipment and shall be included in the Construction Documents.

### 10 13 00. DIRECTORIES

- .1 **DESIGNS:** All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

- .2 **BUDGET ALLOCATIONS:** Building and floor directories are considered Fixed Equipment and included as Signage in the Construction Documents. See Signage for further information.

- .3 **QUANTITIES:** Each building shall have at least one primary directory in the main entrance of the building to serve the entire building. Secondary directories on each floor may be required depending on the complexity of the building.

### 10 14 00. SIGNAGE

- .1 **DESIGNS:** The University has a standardized system for all campus signage. The Associate shall follow the requirements outlined in Appendix S for the development of all signage for a project. All proposals require approval of the Campus Graphics Coordinator in the University Architect prior to finalization of the Construction Documents.

- .2 **BUDGET ALLOCATIONS:** All signage is considered Specialty items or Fixed Equipment and shall be included in the Construction Documents unless otherwise directed by the University Architect. See Appendix S for details.

### 10 14 16. PLAQUES

- .1 **DESIGNS:** Each new or renovated building shall have at least one Building Memorial Plaque and may have numerous Donor Recognition plaques or areas of Donor recognition. Consult with the University Architect for details applicable to each project.

- .2 **BUILDING MEMORIAL PLAQUE:** For new and renovated buildings, the Associate shall make provisions for a wall area in the main lobby or in the vestibule to the main lobby to be used for installation of a 12-inch x 18-inch bronze memorial plaque. The wall area shall be architecturally designed to provide an aesthetic setting for the plaque and shall be adequately lighted. Consult with the University Architect if the plaque is to be part of the Construction Documents or will be provided by the University at a future date. The Associate shall provide adequate blocking or other materials to support the Plaque as part of the Construction Documents.

## **DIVISION 10 - SPECIALTIES**

---

- .3 DONOR RECOGNITION AND ROOM PLAQUES: The Associate shall be aware of and make provisions (space, applicable blocking, utilities and lighting) in the building for donor recognition areas and room plaques. Donor recognition items and the design of donor recognition graphics are funded outside the project budget. The University Architect is responsible for directing the design and installation of donor recognition.

### **10 18 00. INFORMATION KIOSKS**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.
- .2 BUDGET ALLOCATIONS: Information Kiosks are considered Fixed Equipment and included as Signage in the Construction Documents. See Signage for further information.

### **10 20 00. INTERIOR SPECIALTIES**

#### **10 21 00. COMPARTMENTS AND CUBICLES**

##### **10 21 13. TOILET COMPARTMENTS**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.  
Materials: Metal toilet partitions preferred, other materials used only with prior approval.  
Anchors and fasteners: Vandal type screw anchors, toggle bolts, hollow wall anchors or other approved type to suit construction on which items are hung. Wood, lead and plastic plugs are prohibited  
Door latches and pulls: Specify slide latches and pulls for out-swinging doors.
- .2 STANDARD STALL: Spacing shall be 3 ft. o.c. Depth shall be 5'-0". Standard, ceiling hung partitions.
- .3 ADAAG COMPLIANT TOILET PARTITIONS: Standard ceiling mounted partitions. All toilet stalls designated usable by individuals with disabilities shall be 60"x60". The water closet must be located 18" (inches) from the wall or partition. A fraction of 1/4" (inches) either way is an approved installation tolerance. A memorandum describing any departures for ADAAG and/or University standards for accessibility shall be included with the Construction Documents and a copy provided to the ADA Coordinator for the University.

##### **10 21 23. CUBICLES**

###### **10 21 23.13 CUBICLE CURTAINS**

- .1 DESIGNS: All fabrics shall be rated for extra heavy duty commercial use and conform to current OBC.
- .2 BUDGET ALLOCATIONS: Curtains are considered Movable Equipment and are acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction budget.

## **DIVISION 10 - SPECIALTIES**

---

### 10 21 23.16 CUBICLE TRACK AND HARDWARE

- .1 DESIGNS: All track and hardware proposed shall be rated for extra heavy duty commercial use and approved by the University for use.  
  
Necessary blocking, support and services for installation of the Equipment shall be included in the Construction Documents.
- .2 BUDGET ALLOCATIONS: Track and Hardware is considered as part of the Movable equipment purchase. Exceptions to this are instances where powered hardware is required. Powered hardware is considered Fixed Equipment and shall be provided in the Construction Documents.

### **10 22 00. PARTITIONS**

#### 10 22 19. DEMOUNTABLE PARTITIONS

- .1 DESIGNS: Demountable partitions are considered Fixed Equipment and shall be included in the Construction Documents.
- .2 OUTLETS: All power, data and accessory outlets furnished by the manufacturer shall be the same type and quality as those specified in Division 26 of the Construction Documents and conform to current OBC. Note limitations regarding conduit types and sizes.

### **10 28 00. TOILET, BATH AND LAUNDRY ACCESSORIES**

#### 10 28 13. TOILET ACCESSORIES

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.  
The University has selected standard products for use. All proposals shall require approval of the University Architect prior to finalization of the Construction Documents.
- .2 BUDGET ALLOCATIONS: Toilet Accessories are considered Fixed Equipment and shall be included in the Construction Documents.

#### 10 28 13.13 COMMERCIAL TOILET ACCESSORIES

- .1 TOILET TISSUE HOLDERS Available from XPEDX, 1-800-669-7101 (no substitutions):  
  
One (1) per toilet compartment for individuals with disabilities: Continental Dual #830,  
  
One (1) per standard toilet compartment: Kimberly-Clarke # 09686.
- .2 PAPER TOWEL DISPENSERS Available from XPEDX, 1-800-669-7101 (no substitutions): Two (2) per toilet room:  
  
Kimberly-Clarke Automatic Hands Free Roll Towel #D9706 Smoked Gray; with optional pushbutton lock feature; mounting heights: Men=44", Women=40" (floor to bottom of cabinet).
- .3 SOAP DISPENSERS (no substitutions): Supplied by the University, Division of Building Services, Contact the Director as soon as total number is known (number and placement depend on toilet room). Note that there is a 4 week lead time.

## **DIVISION 10 - SPECIALTIES**

---

- .4            **SANITARY NAPKIN DISPENSER (no substitutions):**
- One (1) per Women's toilet room:  
Hospital Specialty Company K-20H Free; Available from Cottingham Paper Company,  
614-294-6444.
- SANITARY NAPKIN RECEPTACLE (no substitution):** One (1) per each two (2) Women's  
toilet compartments:  
Rochester Midland #60 white, sanifloor napkin & tampon disposal unit and five (5) fl  
liners.
- .5            **GARMENT HOOKS:** Each toilet stall shall have a garment hook. The hooks shall be  
mounted on the partition; hooks in stalls for use by individuals with disabilities shall be on  
the partition, reachable from the water closet and approximately 54 in. above the floor.  
Hook can incorporate door bumper hook.
- .6            **SHELVES:** Each toilet room shall have a shelf for books, purses, etc.
- .7            **MIRRORS:** Specify framed mirrors without shelves. If possible, locate mirrors on walls  
opposite lavatories. Specify long mirrors, for use by persons with disabilities, with bottom  
2 ft. above floor and with top located at same height as smaller mirrors. Check and  
coordinate mirror locations to prevent image reflection through room entrances.
- .8            **DIAPER CHANGING STATION (Assembly areas opened to the public)** Specify one  
Diaper Deck for diaper changing for each toilet room.

### **10 40 00. SAFETY SPECIALTIES**

- .1            **EMERGENCY SHOWERS AND EYE WASHES** – The locations of these safety devices  
should be within 50 feet or 10 seconds of a chemical or biological substance deemed  
hazardous. The use of the latest ANSI Z358 standard for these safety devices should be  
specified. ANSI requires the water to be tepid and/or tempered. The devices should not  
be obstructed or be located near other hazards such as electrical outlets and panels.

### **10 43 00. EMERGENCY AID SPECIALTIES**

#### **10 43 16. FIRST AID CABINETS**

- .1            **DESIGNS:** First Aid cabinets shall be furnished and installed by the General Contractor  
and shall be OSHA approved and sized to the using population.

The quantity, selection and locations of First Aid Cabinets are subject to the review and  
approval of the University Architect and designated University personnel.

### **10 44 00. FIRE PROTECTION SPECIALTIES**

#### **10 44 13. FIRE EXTINGUISHER CABINETS**

- .1            **DESIGNS:** All portable fire extinguishers and non-valve cabinets shall be furnished and  
installed by the General Contractor. All portable fire extinguishers and components shall  
conform with National Fire Protection Association (NFPA) Pamphlet 10, latest edition.  
Each extinguisher shall be approved by Underwriter's Laboratory (UL) and bear their  
label.

## DIVISION 10 - SPECIALTIES

---

Provide each locked, break glass fronted fire equipment cabinet with a knocker or other glass breaking means. Attach knocker in a manner that will allow breaking of glass without removing knocker.

An acceptable means of identifying fire extinguisher location must be done by an arrow type sign. See Appendix A, a-1-6.5 of NFPA pamphlet 10.

Cabinets shall be painted steel, flanged recessed (similar to fire hose cabinets), lockable and comparable to the preferred Duo Panel Break Glass style of cabinet manufactured by Larsen's Fire Protection and Safety Equipment. Lock shall be manufactured by Detroit Auto Specialties and shall have a CH751 key. The full fire rating and acoustical rating of the structure walls must be maintained.

Refer to NFPA pamphlet 10, chapters 2, 3, and 4. Chapter 2 is used to determine the classification of potential fires and the rating or relative fire extinguishing effectiveness of various types of extinguishers. Chapter 3 assists in selection of extinguishers which is dependent upon the character of anticipated fires, property construction and occupancy, the vehicle or hazard to be protected, ambient temperature conditions, and other factors. The maintenance of extinguishers is determined by Chapter 4.

.2 APPROVALS: The selection and locations of fire extinguishers are subject to the review and approval of the University Architect and designated University personnel. Extinguishers meeting the described requirements, including those manufactured by Fire Chief, Kidde, and General, will be considered for acceptance.

.3 CONSTRUCTION COORDINATION: Penetration of walls by cabinets or other penetrations, unless openings and voids are sealed with fireproof materials, is prohibited. Fire-rated walls must not have the rating reduced by penetrations or reduction of thickness.

### 10 44 16. FIRE EXTINGUISHERS

.1 DESIGNS: All fire extinguishers are to be complete, tested, certified, ready for use, and conform to the following:

CARBON DIOXIDE EXTINGUISHERS: Red enameled-steel or aluminum equipped with valve, discharge hose and horn, squeeze-grip lever, and mounting bracket, if not cabinet installed. Minimum rating 5 BC.

MULTI-PURPOSE EXTINGUISHERS: Red enameled-steel, pressurized type equipped with pressure gauge, discharge nozzle, squeeze-grip lever, and mounting bracket, if not cabinet installed. These extinguishers are dry chemical for Class A, B, and C fires. Minimum rating 4A 60 BC.

SPECIAL EXTINGUISHERS: Fully equipped types for use on the specific Class D combustible metal hazards and Class K Food Service Operations.

For computer rooms, expensive laboratory installations and similar locations, which must be protected from damage, provide Halon 1211 with at least 9 lbs. 1A 10BC rating.

## DIVISION 10 - SPECIALTIES

---

### 10 50 00. STORAGE SPECIALITES

### 10 55 00. POSTAL SPECIALTIES

- .1 DESIGNS: The Associate shall provide a primary Mail Room for US Mail and University Mail delivery and distribution adjacent to the building entrance or loading dock for each new building or building renovation. Room size shall be applicable to the number of departments serviced in the building and volume of delivery. Minimum room size shall be 100 square feet. Secondary Mail Rooms on upper floors may be required for applicable distribution.

Postal facilities, serviced by the U.S. Postal Service, are subject to inspection and approval by the Customer Service Section of the U.S. Postal Service. during the planning process and arrange for examination of construction documents for conformance to regulations and inspection of the installation(s) during construction.

All Postal product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

- .2 BUDGET ALLOCATIONS: Unless otherwise noted, Postal Mail Room and Distribution Equipment is considered Fixed Equipment and shall be included in the Construction Documents.

- 3 CONSTRUCTION COORDINATION: The Associate is to coordinate all requirements and services leading to Postal Equipment locations on the Construction Drawings. Penetration of walls or floors by chutes and boxes, unless openings and voids are sealed with fireproof materials, is prohibited. Fire-rated walls or floors must not have the rating reduced by penetrations or reduction of thickness.

### 10 55 13. CENTRAL MAIL DELIVERY BOXES

- .1 INDIVIDUAL MAIL BOXES: Located at the Mail Room. U.S. Postal Standard Equipment sizes. Unless otherwise stipulated in the Program of Requirements, one box shall be provided for each faculty/staff member in the building. Boxes shall be installed for loading from inside Mail Area and unloading from corridor. Corridor door locks shall be fitted with Best cylinders, keyed to the University keying system. Fronts of boxes shall be numbered in sequence determined by the University. Rear of each box shall be provided with label holder, or equivalent, for identification. **Custom Millwork mail sorter boxes are prohibited.**

- .2 DEPARTMENTAL MAIL BOXES: Located at the Mail Room. U.S. Postal Standard Equipment sizes. Unless otherwise noted in the Program of Requirements, one Department Box shall be provided for each Department. Size boxes for Department volume needs. Boxes shall be installed for loading from inside the Mail Room and unloading from the corridor. Corridor door locks shall be fitted with Best cylinders, keyed to the University keying system. Front of boxes shall be numbered in sequence determined by the University. Rear of box shall be provided with label holder, or equivalent for identification. **Custom Millwork mail sorter boxes are prohibited.**

- .3 MOVABLE EQUIPEMENT SORT MODULES: For open mail distribution in secure department areas, adjustable Movable Equipment open mail sorters may be used for each faculty/staff member. Only adjustable mail system equipment which utilizes standard, legal and oversize shelf dividers suited for common sizes of mail shall be considered. **Custom millwork mail sorter units are prohibited.**

## **DIVISION 10 - SPECIALTIES**

---

### 10 55 16. MAIL COLLECTION BOXES

- .1 U.S. POSTAL SERVICE STANDARD BOX: One standard wall-mounted box, officially approved by the U.S. Postal Service, shall be installed at a first floor Mail Room or in the main lobby or entrance way of each building. All regulation markings shall be provided. This box must be located within 100 feet of an entrance at which the Postal vehicle can be parked. Locks must conform to Postal Regulations. Depending upon who picks up the mail, a campus key may be provided.

### **10 56 00. STORAGE ASSEMBLIES**

#### 10 56 13. METAL STORAGE SHELVING

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents. The building design and Construction Documents must include all structural requirements, services and construction coordination for the installation of this equipment.
- .2 BUDGET ALLOCATIONS: Metal Storage Shelving shall be considered Fixed Equipment and are funded within the Construction Budget. In some cases, the University may choose to purchase Metal Storage Shelving for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase.

#### 10 56 26. MOBILE STORAGE SHELVING

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents. The building design and Construction Documents must include all structural requirements, services and construction coordination for the installation of this equipment.
- .2 BUDGET ALLOCATIONS: Mobile Storage Shelving shall be considered Fixed Equipment and are funded within the Construction Budget. In some cases, the University may choose to purchase Mobile Storage Shelving for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase.

### **10 57 00. WARDROBE AND CLOSET SPECIALTIES**

#### 10 57 13. HAT AND COAT RACKS

- .1 DESIGNS: Wall and door mounted coat hooks and all blocking shall be included in the Construction Documents for offices and conference areas.
- .2 CONSTRUCTION COORDINATION: With the exception of wall and door mounted coat hooks, other Accessory items may be provided by the University. A list of University furnished items will be submitted to the Associate for appropriate Construction Document coordination of blocking or placement. Rough layouts, showing the placement of all accessories, must be submitted with the schematic and design development submittals.



## **DIVISION 10 - SPECIALTIES**

---

**10 80 00 OTHER SPECIALITIES**  
**10 82 00. GRILLS AND SCREENS**

10 82 13. EXTERIOR GRILLS AND SCREENS

- .1           DESIGNS: Louvers and vents for air distribution systems should be specified in Division 23. The HVAC Contractor shall be required to furnish and install all interior louvers and vents. If such items are an integral part of the exterior design of a building and are not connected directly to an air distribution system, specify that the General Contractor purchase and install them.

---

## **END OF DIVISION 10 - SPECIALTIES**

## **DIVISION 11 - EQUIPMENT**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **11 00 00. EQUIPMENT**

#### **11 00 03. GENERAL PROVISIONS**

- .1 Refer to Division 00 PROCESSING THE WORK, PART ONE – THE DESIGN PROCESS, paragraph 00037, Furniture, Fixtures and Equipment (FF&E)
- .2 DESIGNS: The A/E shall provide layouts of both Movable and Fixed Equipment identified in the POR to ascertain function and space usage for the project. Submittals are required as outlined in the Architect/Engineer (A/E) Agreement for Basic Services.
- The A/E shall specify all utility fittings and fixtures for equipment equal to that specified for the Divisions for Facilities Services Subgroup.
- The A/E shall specify that all Automatic Shut-off Valves have a 10 year written warranty.
- .3 CONSTRUCTION COORDINATION: The A/E shall clearly define contractor responsibilities relative to receiving, storage and installing. Installation is to include any hook-up required.
- The A/E is to locate and coordinate all blocking, support and services for installation of all items in this Division.

### **11 01 92 FALL PROTECTION (ROOFS)**

#### **Part I – GENERAL**

- .1.1 COMMENTARY
- .1.1.1 The intent of this standard is to ensure the safety of all authorized OSU employees performing work on roofs at the University and provide a safe work area.
- .1.1.2 It is the intent of the University to not use mechanical attachment points, cables, or any other device that requires certification.
- .1.1.3 A more permanent passive means of fall protection to prevent a fall is preferred. Such means include parapet walls and guardrail systems.
- .1.2 REFERENCES
- .1.2.1 ANSI A10.32-2004 Fall Protection Systems for Construction and Demolition Operations
- .1.2.2 ANSI Z359.0-2007 Definitions and Nomenclature Used for Fall Protection and Fall Arrest
- .1.2.3 OSHA 29 CFR PART 1910 Subpart D Walking and Working Surfaces
- .1.2.4 OSHA 29 CFR PART 1910 Subpart I Personal Protective Equipment
- .1.2.5 OSHA 29 CFR PART 1926 Subpart M Fall Protection

## DIVISION 11 - EQUIPMENT

---

### .1.3 DEFINITIONS

- .1.3.1 Fall Protection – Any equipment, device or system that prevents an accidental fall from elevation or that mitigates the effect of such a fall.
- .1.3.2 Fall Arrest System – The equipment components that are configured to arrest (stop) a free-fall.
- .1.3.3 Travel (Fall) Restraint System – A device or devices (e.g. a lanyard short enough) that limits travel to prevent a user's center of gravity from reaching a fall hazard.
- .1.3.4 Safe Work Zone – The area of a roof demarcated to indicate that work can safely be performed without the use of fall protection.

### Part II – PRODUCTS

.2.1 To ensure the safety of authorized OSU employees working on roofs, the design team is to generate a design & drawings for:

- .2.1.1 Establishing a safe work environment
- .2.1.2 A method of performance of the most work with the least impact to workers
- .2.1.3 A method to perform all maintenance items required on the particular roof.
- .2.1.4 Fall protection system requiring minimum maintenance, no annual certification, and least aesthetic impact to the building.
- .2.1.5 The use of mechanical anchor points or horizontal life lines are to be used only with the concurrence of the Project Manager, TSG, Operations, and EHS.

**Commentary:** *the following approaches can be considered in order of preference:*

- .1 A 42" parapet is to be around the perimeter of the roof.
- .2 A 42" guardrail - is to be around the perimeter of the roof.
- .3 A "Safety Line" of a different color than the roof is to be installed 10' from all edges of the roof defining a "Safe Work Zone" which the workers must remain within. All equipment and roof drains must be able to be maintained within the Safe Work Zone.
- .4 If the roof edge requires maintenance, it must be accessed from a bucket truck or other means from the ground.
- .5 If any work on a roof is required outside the "Safe Work Zone", an outside contractor, responsible for their own fall protection, is to be called for the investigation and repair.

### .2.2 SIGNAGE

2.2.1 Following the University's Sign Standards, a laminated sign shall be posted on all entry points to the roof reinforcing safe work practices.

**Commentary:**

As an example: "No OSU employee is permitted outside the Safe Work Zone. If work is required outside the Safe Work Zone, a contractor is to be hired."

## DIVISION 11 - EQUIPMENT

---

- .2.2.2 A laminated roof plan is to be posted adjacent the above signage illustrating the Safe Work Zone which the OSU authorized worker must remain within.

### .2.4 OTHER ROOF HAZARDS

- .2.4.1 Any roof opening has a potential for causing falls, trips or hazards from objects falling through the opening.
- .2.4.2 Openings including skylights and small openings shall be protected by use of guardrails, covers, or other fall protection measures as appropriate.
- .2.4.3 Roof hatches shall be protected by guardrails with a safety swing gate.
- .2.4.4 Additional locations that shall be designed to include fall protection measures as an essential part of the design include catwalks, areas above dangerous equipment, and hoist areas. Refer to OSHA regulations for additional details.
- .2.4.5 Toe-boards shall be provided where appropriate as a protection from falling objects
- .2.4.6 Ladders: provide guardrails, safety swing gate and platforms as required to provide a safe pathway from the roof edge for a minimum distance of six (6) feet.

### **11 10 00. VEHICLE AND PEDESTRIAN EQUIPMENT**

#### **11 13 00. LOADING DOCK EQUIPMENT**

- .1 **DESIGNS:** All product specifications, accessory items, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

Dock doors shall be at least 9'-0" wide and should be 12'-8" minimum on center when multiple doors are used. Pavement slope is a serious concern relative to drainage and to truck bed floor/building floor/canopy relationship. Loading docks shall be at the same elevation as a floor of the building and shall be either 44 inches minimum to 46 inches maximum above the adjacent pavement or shall be provided with a load leveler. Check height requirements with the University Architect; a different dock height might be required if step van vehicles, only, are used. Loading docks must not be located at or near fresh air intakes for buildings. Unless this is done, the exhaust from idling vehicles will be drawn into buildings and expose inhabitants to toxic airborne contaminants.

- .2 **BUDGET ALLOCATIONS:** All Loading Dock Equipment is considered Fixed Equipment and acquired through one or more of the Construction contracts within the project budget

#### **11 14 00. PEDESTRIAN CONTROL EQUIPMENT**

- .1 **DESIGNS:** All product specifications, accessory items, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

If the Program of Requirements calls for pedestrian control but does not detail the requirements for pedestrian control, the University Architect will consult the using agency and the Department of Public Safety and will indicate the kind of control devices required.

## **DIVISION 11 - EQUIPMENT**

---

Control devices shall be planned to provide ample room for the passage of wheelchairs and crutches. The University Architect will review these devices for clearances per ADA requirements.

- .2 CONSTRUCTION COORDINATION: The A/E is to coordinate all Pedestrian control devices that are used in conjunction with electronic security systems. Installations will require close coordination with electrical installations.

### **11 20 00. COMMERCIAL EQUIPMENT**

#### **11 21 00. MERCANTILE AND SERVICE EQUIPMENT**

##### **11 21 23. VENDING EQUIPMENT**

- .1 DESIGNS: Vending equipment will be provided under separate contracts with a franchisee. All required power, data, plumbing, lighting and planning for these services shall be a part of the Construction Documents.

### **11 24 00. MAINTENANCE EQUIPMENT**

- .1 DESIGNS: All product specifications, accessory items, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents. The A/E shall be alerted to plan for the storage and service needs of all equipment within maintenance rooms.
- .2 BUDGET ALLOCATIONS: Fixed maintenance equipment will be acquired through one or more of the Construction contracts within the project budget. Movable service maintenance equipment for a project is acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction budget.

### **11 26 00. UNIT KITCHENS**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.
- .2 BUDGET ALLOCATIONS: Fixed Unit Kitchens shall be considered Fixed Equipment and are funded within the Construction Budget.

### **11 28 00. OFFICE EQUIPMENT**

- .1 Refer to DIVISION 00 PROCESSING THE WORK, PART ONE – THE DESIGN PROCESS, paragraph 00037, Furniture, Fixtures and Equipment (FF&E) and Division 12 Furnishings.

### **11 29 00. POSTAL, PACKAGING AND SHIPPING EQUIPMENT**

- .1 Refer to Division 10 Specialties and Division 12 Furnishings.
- .2 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

## **DIVISION 11 - EQUIPMENT**

---

- .3 BUDGET ALLOCATIONS: Fixed Postal and Shipping Equipment shall be considered Fixed Equipment and are funded within the Construction Budget. Movable Postal and Shipping Equipment is considered Movable Equipment and acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction budget.

### **11 50 00. EDUCATIONAL AND SCIENTIFIC EQUIPMENT**

#### **11 51 00. LIBRARY EQUIPMENT**

##### **11 51 19. BOOK THEFT PROTECTION EQUIPMENT**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

- .2 BUDGET ALLOCATIONS: Theft Protection and security equipment items shall be considered Fixed Equipment and are funded within the Construction Budget.

##### **11 51 23. LIBRARY STACK SYSTEMS**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents. The Building Design and Construction Documents must include all structural requirements, services and construction coordination for the installation of this equipment.

- .2 BUDGET ALLOCATIONS: Library Stack Systems shall be considered Fixed Equipment and are funded within the Construction Budget. In some cases, the University may choose to purchase Library Stack Systems for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase.

##### **11 51 23.13 METAL LIBRARY SHELVING**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents. The Building Design and Construction Documents must include all structural requirements, services and construction coordination for the installation of this equipment.

The University has selected standard products for use. All proposals shall require approval of the University Architect prior to finalization of the Construction Documents.

- .2 BUDGET ALLOCATIONS: Metal Library Shelving shall be considered Fixed Equipment and are funded within the Construction Budget. In some cases, the University may choose to purchase Metal Library Shelving for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase.

#### **11 52 00. AUDIO VISUAL EQUIPMENT**

- .1 DESIGNS: Audio-Visual equipment is considered Technology. Both Fixed and Movable Technology design and specifications will be provided by the University through separate Contracts. The timing for technology design must coincide with the development of Design and Construction Documents prior to bidding. The A/E must be involved in the development of the technology design and be responsible for the coordination of

## **DIVISION 11 - EQUIPMENT**

---

equipment locations, required blocking and other construction needs, required power, data and associated services to this equipment.

.2 BUDGET ALLOCATIONS: Audio-Visual Equipment shall be considered Fixed Equipment or Movable Equipment.

.2.1 FIXED EQUIPMENT: Examples of Fixed Audio-Visual Equipment are motorized projection screens and projector lifts which need to be provided and installed by a General Contractor.

.2.2 MOVABLE EQUIPMENT: Examples of Movable Equipment are projectors, speakers, equipment racks, rack equipment and podiums.

.3 CONSTRUCTION COORDINATION: The A/E is to coordinate all required power and services leading to Fixed and Movable Audio-visual locations on the Construction Drawings. Provide detailed riser diagrams and special attention to ceiling mounted projectors locations, equipment rack locations, and podium locations. The ceiling projector pole mount and location will be provided for Construction Contractor installation.

### **11 52 13. PROJECTION SCREENS**

.1 DESIGNS: The University will provide detailed specifications for all classroom and conference room projection screens.

.2 MOTORIZED AND RECESSED SCREENS: All motorized and recessed ceiling screens will be considered Fixed Equipment and provided as part of the Construction Documents.

.3 WALL MOUNTED PROJECTION SCREENS: All classroom and conference room projection screens will be considered Fixed Equipment and provided as part of the Construction Documents.

### **11 53 00. LABORATORY EQUIPMENT**

.1 Refer to Appendix W for Laboratory equipment details.

.2 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

.3 BUDGET ALLOCATIONS: Unless otherwise noted, all Laboratory equipment items shall be considered Fixed Equipment and are funded within the Construction Budget. In some cases the University may choose to purchase metal Laboratory shelving for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase.

### **11 55 00. PLANETARIUM EQUIPMENT**

.1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

.2 BUDGET ALLOCATIONS: Unless otherwise noted, all Planetarium equipment shall be considered Fixed Equipment and are funded within the Construction Budget.

## **DIVISION 11 - EQUIPMENT**

---

### **11 56 00. OBSERVATORY EQUIPMENT**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.
- .2 BUDGET ALLOCATIONS: Unless otherwise noted, all Observatory equipment shall be considered Fixed Equipment and are funded within the Construction Budget.

### **11 60 00. ENTERTAINMENT EQUIPMENT**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.
- .2 BUDGET ALLOCATIONS: Unless otherwise noted, all Entertainment Equipment shall be considered Fixed Equipment and are funded within the Construction Budget. Exceptions to this are smaller Movable Equipment items which will be purchased by the University as Movable Equipment.

### **11 65 00. ATHLETIC AND RECREATIONAL EQUIPMENT**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.
- .2 BUDGET ALLOCATIONS: All Athletic and Recreational Equipment shall be considered Fixed Equipment and are funded within the Construction Budget. Exceptions to this are smaller Movable Equipment items which are acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction budget.

### **11 70 00. HEALTHCARE EQUIPMENT**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.
- .2 BUDGET ALLOCATIONS: All Healthcare Equipment shall be considered Fixed Equipment and are funded within the Construction Budget. In some cases, the University may choose to purchase Healthcare Equipment for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase.
- .3 Smaller Movable Equipment items are considered movable equipment and are acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction budget.

---

**END OF DIVISION 11 - EQUIPMENT**



## **DIVISION 12 - FURNISHINGS**

2006 Edition, Published January 1, 2006; Division Revision Date: November 30, 2015

### **12 00 00. FURNISHINGS**

#### **12 00 03. GENERAL PROVISIONS**

- .1 Refer to PART ONE, paragraph 00037, Fixtures, Furniture and Equipment (FF&E)
- .2 **DESIGNS:** The Architect/Engineer (A/E) shall provide layouts of both Movable and Fixed Furnishings identified in the Program of Requirements (POR) to determine function and space usage for the project. Submittals are required as outlined in the A/E Agreement for Basic Services.
- .3 **CONSTRUCTION COORDINATION:** The A/E is to coordinate all required power voice and data services leading to Fixed and Movable Furnishings locations on the Construction Drawings. Provide any details and drawings necessary for critical dimensions and locations of furnishings.

The A/E is to locate and coordinate all blocking, support and services for installation of all items in this Division.

#### **12 10 00. ART (deleted)**

### **12 20 00. WINDOW TREATMENTS**

- .1 **DESIGNS:** The A/E shall provide treatment to all windows applicable to the building design and functions. All windows treatment, interior and exterior, is integral to the energy management of the building, the control of light and comfort of the occupants. All proposed manufacturer products and hardware must be rated for extra heavy duty commercial use.
- .2 **APPROVALS:** All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.
- .3 **CONSTRUCTION COORDINATION:** The building design and Construction Documents must include all structural requirements, blocking, services and construction coordination for the installation of Window Treatment.

## DIVISION 12 - FURNISHINGS

### 12 21 00. WINDOW BLINDS

- .1 BUDGET ALLOCATIONS: Window Blinds shall be considered Fixed Equipment and are funded within the Construction Budget. In some cases, the University may choose to purchase Window Blinds for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase.

### 12 22 00. CURTAINS AND DRAPERIES

- .1 BUDGET ALLOCATIONS: Curtain and Draperies shall be considered Movable Equipment and are acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction budget.

### 12 23 00. INTERIOR SHUTTERS

- .1 BUDGET ALLOCATIONS: Interior Shutters shall be considered Fixed Equipment and are funded within the Construction Budget.

### 12 24 00. WINDOW SHADES

- .1 BUDGET ALLOCATIONS: Window Shades shall be considered Fixed Equipment and funded within the Construction Budget. In some cases, the University may choose to purchase Window Shades for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase.

- .2 SHADECLOTH GUIDELINE APPLICATION: Shadecloth and other window coverings directly affect the HVAC efficiency and overall comfort of a space (brightness and glare). Some projects will require a minimum shading coefficient or solar factor by the mechanical engineer. Primary considerations for shadecloth application are:

- SHADING COEFFICIENT (percentage of solar heat through a combination of glass and specific shadecloth. Light colors have a lower shading coefficient and lower heat gain than dark colors).
- SOLAR OPTICAL PROPERTIES (used to calculate the shading coefficient with glass and shadecloth combination)
- VISIBLE LIGHT TRANSMITTANCE (DAYLIGHT). Glare and brightness control is a primary consideration.
- OPENNESS FACTOR (DENSITY) of the shadecloth weave.
- COLOR of the shadecloth will directly affect the Shading Coefficient, brightness and glare. Light colors are more reflective with lower heat gain and shading coefficient but with higher percentage of daylight and solar transmittance. Light colors are brighter when sunlit which causes high surface brightness. Light colors are difficult to see through. Dark colors are viewable through the shadecloth to the outside. Dark colors absorb light and heat and are less energy efficient. Dark colors lower surface brightness and provides glare free environments. Medium value colors minimize excessive contrast in a room and reduces eye strain.

The OPENESS FACTOR (OF) is a key element to consider once a shadecloth has met shading coefficient requirements.

OF at 0% – Privacy and room darkening (Opaque). Example - MechoShade ThermoVeil 0700 Series (Budget Vinyl) and MechoShade Midnight Blackout 0200 Series

OF at 1% - Privacy at night (Translucent shadecloth). Example - MechoShade ThermoVeil 0900 series

## DIVISION 12 - FURNISHINGS

OF at 2% - Visible Light Transmittance is 100%>80%. Example – MechoShade EuroTwill 6200 Series

OF at 3% - Visible Light Transmittance is 90%>60%. Example – MechoShade ThermoVeil 1500 Series and EuroTwill 6000 Series.

OF is 5% - Visible Light Transmittance is 50%>35%. Example – MechoShade ThermoVeil 1300 Series

OF is 8% - Visible Light Transmittance is 30%>22%.

OF is 15% - Visible Light Transmittance is 20% or less.

### 12 25 00. WINDOW TREATMENT OPERATING HARDWARE

- .1 CONSTRUCTION COORDINATION: Necessary power, electrical controls and other devices for installing window treatment shall be included in the Construction Documents.

### 12 30 00. CASEWORK

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

The A/E shall specify all utility fittings and fixtures for Casework equal to that specified for the Plumbing, HVAC, Electrical and Data Communications.

- .2 BUDGET ALLOCATIONS: Casework shall be considered Fixed Equipment and funded within the Construction Budget.

### 12 40 00. FURNISHINGS AND ACCESSORIES

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Contract Documents.

The A/E shall specify all utility fittings and fixtures for Furniture equal to that specified for the Plumbing, HVAC, Electrical and Data Communications.

- .2 BUDGET ALLOCATIONS: Furniture shall be considered Movable Equipment and acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction budget.

## **DIVISION 12 - FURNISHINGS**

- .3 CONSTRUCTION COORDINATION: Necessary structural support, power, data, utilities and other support for Furnishings and Accessories shall be included in the Construction Documents.

### **12 48 00. RUGS AND MATS**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

#### **12 48 13. ENTRANCE FLOOR MATS AND FRAMES**

- .1 DESIGNS: At entrance doors to buildings, entrance floor mats shall be in recessed frames wherever possible.
- .2 BUDGET ALLOCATIONS: Recessed Entrance floor mats and frames shall be considered Fixed Equipment and funded within the Construction Budget.

#### **12 48 53. RUGS**

- .1 BUDGET ALLOCATIONS: Loose rugs shall be considered Movable Equipment and acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction Budget.

### **12 50 00. FURNITURE**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Contract Documents.

The A/E shall specify all utility fittings and fixtures for Furniture equal to that specified for the Plumbing, HVAC, Electrical and Data Communications.

- .2 BUDGET ALLOCATIONS: Furniture shall be considered Movable Equipment and acquired by the University utilizing a fund allocation within the total project funds but independent of the Construction budget.
- .3 CONSTRUCTION COORDINATION: The A/E shall plan and include required structural support, power, data, utilities and other support for Furnishings and Accessories in the Construction Documents.

### **12 60 00. MULTIPLE SEATING**

- .1 DESIGNS: All product specifications, accessory items, colors, finishes, applications and details are to be reviewed and approved by the University Architect prior to the final development of the Construction Documents.

The A/E shall specify all utility fittings and fixtures for Furniture equal to that specified for the Plumbing, HVAC, Electrical and Data Communications.

In areas of assembly, the A/E shall show generic seating layouts, demonstrating seating volumes, aisle dimensions etc. as required for Schematic and Design Development Submittals. All seating layouts shall conform to current Ohio Building Code requirements.

## **DIVISION 12 - FURNISHINGS**

- .2 BUDGET ALLOCATIONS: Unless otherwise noted, Multiple Seating shall be considered Fixed Equipment and funded within the Construction Budget. In some cases, the University may choose to purchase Multiple Seating for a project. In these cases, the cost of the equipment is moved from Construction funds to Equipment funds for purchase.
- .3 CONSTRUCTION COORDINATION: Necessary structural support, power, data, utilities and other support for Furnishings and Accessories shall be included in the Construction Documents.

Detailed shop drawings and field verification required from the Manufacturer prior to approval and installation.

### **12 61 00. FIXED AUDIENCE SEATING**

- .1 MATERIALS AND CONSTRUCTION: The A/E shall indicate complete specifications showing manufacturer, product number, materials and details from a selected product and at least two additional manufacturers, product numbers, materials and details showing equal compatibility.

The University has selected standard products for use. All proposals shall require approval of the University Architect prior to finalization of the Construction Documents.

- .2 FOLDING TABLET ARMS: Unless otherwise noted by the University, all auditorium and lecture hall seating is required to have articulating one motion tablet arms.

Tablet construction to be laminated birch plywood core with finished birch or permanent/integral edges and laminated on both sides with plastic laminate. PVC "T" or self-edges are not acceptable. Tablet arms are to be full size without curves and indents that reduce useable work surface. The minimum tablet arm size is to be a rectangular shape 143 square inches or more with no cutouts within the rectangle. Ten to twelve percent (10-12%) of the tablet arms are to be left-handed. Left-handed seats shall be located to avoid interference with right-handed tablets. Provide clearance of 8" or more from top of seat to underside of tablet arm when open.

- .3 SEAT AND BACK: Chair back and seat shall be two part (separate) construction. All components including upholstery shall be easily field replaceable. Provide gravity seat and articulating back. Provide minimum of 23" seat width on center and 18" seat depth. Provide minimum back height of 35" from seat. Upholstery fabric to be a minimum 200,000 double rubs composed of nylon or nylon blend.

- .4 ARM CAPS/ARMRESTS: Arm caps and armrests shall be finished wood or molded polyurethane material. Plastic laminate and upholstered armrests are prohibited. Provide minimum arm rest width of 2".

- .5 MOUNTING: Specify only beam or riser mounted applications to facilitate maintenance. Newly constructed facilities shall be planned accordingly.

- .6 WARRANTIES AND GUARANTEE: Specify that the manufacturers guarantee the product and carry a minimum of 5 year complete warranty on all components. Throughout this five year period, the product will not show signs of excessive wear or deterioration or experience failure of any item material, construction or finish or the manufacturer shall promptly repair or replace equipment showing defects of material at no cost to the University.

## DIVISION 12 - FURNISHINGS

### 12 93 00. SITE FURNISHINGS (Added 2/9/2007)

#### 12 93 13. BICYCLE RACKS:

The following is the basis of design. Final A/E selections shall be reviewed by the University Landscape Architect for final approval.

- .1 DuMor, Model: #83-00G galvanized loop, S-1 Embedment, 2-3/8" O.D. x 11-gauge wall galvanized steel tube as supplied by Service Supply, LTD. Columbus, OH, 614-861-3681.

#### 12 93 23. TRASH RECEPTORS

##### .1 PLAZA STYLE TRASH RECEPTORS:

The following is the basis of design. Final A/E selections shall be reviewed by the University Landscape Architect for final approval.

DuMor, inc. Model 157-32-25BT (side loading), 32 gallon litter receptacle, color: Black supplied by Service Supply, LTD. Columbus, OH, 614-861-3681.

#### 12 93 43. SITE SEATING AND TABLES

##### .1 PLAZA STYLE BENCH:

The following is the basis of design. Final A/E selections shall be reviewed by the University Landscape Architect for final approval.

DuMor, inc. Model 93-60, 6 foot long metal bench, color: Black. Supplied by Service Supply LTD., Alan Kletecka, Columbus, OH, 614-861-3681.

##### .2 PLAZA STYLE PICNIC TABLE:

The following is the basis of design. Final A/E selections shall be reviewed by the University Landscape Architect for final approval.

Dumor #63-303-4 (or 3 for ADA accessible)/S-5 Picnic Table surface mount, Color: black. Supplied by Service Supply, LTD. Columbus, OH, 614-861-3681.

##### .3 PARK STYLE PICNIC TABLE:

Use only for repair / replacement after review with the University Landscape Architect.

Harvest Picnic Table, Model 2107X/RW, 84" x 233" x 30"(h) table with exposed aggregate finish and redwood bench assembly, as supplied by Aerocrete dba Architectural Precast 5660 Limaburg Road, Burlington, KY 41005-9398, 1-800-542-1738..

Concrete Pad, Model #9000, 8' x 9' x 4' Concrete pad, as supplied by Aerocrete dba Architectural Precast 5660 Limaburg Road, Burlington, KY 41005-9398, 1-800-542-1738.

---

END OF DIVISION 12 - FURNISHINGS

**DIVISION 13 - SPECIAL CONSTRUCTION**

2006 Edition, Published January 1, 2006; Division Revision Date: January 1, 2006

**13 00 00. SPECIAL CONSTRUCTION**

**13 07 00. INTEGRATED CEILINGS**

.1 COORDINATION OF INSTALLATION: It is preferred that integrated ceilings be made a part of the General Contract and the General Contractor be required to coordinate the complete installation, including the work of the HVAC and Electrical Contractors. If the Associate feels that such ceilings should be installed by either of the other contractors, he should discuss the matter with the University Architect during the review conference for Design Development submittal. The Associate's HVAC and electrical consultants shall be present at this discussion.

**13 34 00. PRE-ENGINEERED STRUCTURES**

.1 ENGINEERING DATA REQUIRED: An analysis of framing and structural components is required. Data shall bear the seal and signature of a professional architect or engineer, registered in Ohio, attesting that the structures meet requirements of the specifications and comply with requirements of the OBC. Copies of this data shall be submitted to the University Architect.

**13 49 00. RADIATION PROTECTION**

.1 MATERIAL STANDARDS AND INSTRUMENTATION: Materials and equipment shall conform to applicable recommendations of the National Council on Radiation Protection and Measurements Reports No. 33, 34, 35, and 36, and shall be furnished and installed in accordance with the Code of Federal Regulations, Department of Health, Education, and Welfare (FDA Division). Installation shall be in strict adherence with manufacturer's requirements and approved shop drawings.

NCRP Report No.	Title
33	Medical X-ray and Gamma Ray Protection for Energies up to 10 MeV-Equipment Design and Use
34	Medical X-ray and Gamma Ray Protection for Energies up to 10 MeV-Structural Shielding Design and Evaluation
35	Dental X-ray Protection
36	Radiation Protection in Veterinary Medicine

When planning a structure containing facilities in which radioactive materials are to be used, such as laboratories or certain hospital rooms, the following references should be consulted:

Brodsky, A., Determination of facilities, equipment, and procedures requires for various types of operations, in "Handbook of Radioactive Nucleides", Wanh Y., Ed. CRC Press, Boca Raton, FL 1969, pp. 664-710.

**13 49 00. RADIATION PROTECTION (Cont'd)**

**.1 MATERIAL STANDARDS AND INSTRUMENTATION: (Cont'd)**

Brodsky, A., Determining industrial hygienics requirements for installations using radioactive materials, in Handbook of Laboratory Safety", 2nd ed., Steere, NV, ED. Chemical Rubber Company, Cleveland, OH, 1971, pp. 482-502.

U.S. Nuclear Regulatory Commission, Regulatory Guides 1.86 and B.23 (Since they address surface contamination limits).

International Atomic Energy Agency - Safety Series books

No. 91982, Basic Safety Standards for Radiation Protection

No. 381973, Radiation Protection Procedures.

These references, and others are available for review at the Ohio State University Office of Radiation Safety, B-042 Graves Hall 333 W. 10th Avenue (614-292-0122). Associates architects are encouraged to contact radiation safety officer here if there are any questions about facility suitability.

**.2 TESTING:** After the X-ray equipment has been installed and placed in operating condition, a radiation survey shall be performed by a qualified expert as recommended by NCRP. After radioactive material containment facilities are placed in operating condition, air flow rates shall be measured by a qualified expert at all intakes and exhaust points of the ventilation system affected.

**.3 LISTING REQUIRED:** The University Office of Radiological Health and Safety has the responsibility of registering all sources of radiation generated by an electronic product, subject to Radiation Control for Health and Safety Act of 1968. A listing of all such devices, as well as all radioactive materials specified in the contract documents, shall be submitted by the Associate to the University Architect with those documents. Devices include, but are not necessarily limited to:

lasers and maser  
radar  
microwave generators  
electron microscopes  
infrasonic, sonic, and ultrasonic generators  
X-ray generators and accelerators  
electron welders  
diatherapy units  
infrared and ultra-violet sources  
TV sets (of the projection type only)

---

END OF DIVISION 13 - SPECIAL CONSTRUCTION



## **DIVISION 14 - CONVEYING SYSTEMS**

2006 Edition, Published January 1, 2006; Division Revision Date: January 1, 2006

### **14 00 00. CONVEYING SYSTEMS**

#### **14 20 00. ELEVATORS**

.1 PLANNING CONFERENCE: The Associate shall arrange with the University Architect for a meeting to discuss elevator requirements with University personnel.

.2 USE OF EXISTING ELEVATORS: Refer to Division 01, paragraph 01 54 13.2. If University permission is granted to use existing elevators, the contractor should be alerted that elevators will be inspected by Facilities Operations and Development personnel before and after construction to appraise any damage caused by this use. The General Contractor shall be required to arrange and pay for maintenance during the period, and to restore interiors of cabs to original condition before the final project payment is authorized. Pending approval by the University Architect's Office, the Associate shall designate the appropriate elevator for use.

#### 14 20 01. GENERAL REQUIREMENTS:

.1 CONTRACT: Except as otherwise approved by the University, elevators shall be included in the general contract. Specify that all wiring installed by the elevator contractor shall comply with Division 26 of the specifications.

.2 PROVISIONS FOR SERVICING: The elevator manufacturer shall be required to provide evidence that a staffed service office is located within 50 miles of the installation and a warehouse of parts is maintained within 100 miles. Acceptable Columbus area companies will have a history of more than five years of continuous Columbus area elevator design, construction and maintenance experience. Maintenance and callback service shall be provided for one year from date of elevator acceptance. Include the following provisions in the specifications:

.2.1 MAINTENANCE BY MANUFACTURER: Furnish total maintenance servicing for a period of one year beginning on the date of University acceptance of elevator. Service shall include scheduled regular examinations of the equipment, during regular work hours by competent, trained employees of the manufacturer. The maintenance shall include necessary adjustments, greasing, oiling, cleaning, supplies, and parts to keep equipment in proper operation, except repairs made necessary by misuse, accidents, or negligence not caused by the manufacturer. Frequency of maintenance service will be established by the University Architect during the specification writing period, based on location and use of elevator. The contractor shall respond to all calls within forty-five (45) minutes after notification, including evening and weekends. Trapped passengers require immediate response and are to be treated at the highest emergency level. Failure to respond promptly or to provide competent service will be cause to hire another contractor to perform the work at the expense of the installing contractor.

.2.2 INSTRUCTIONS FOR MAINTENANCE PERSONNEL: The installer will furnish three copies of: final wiring diagrams, technical manuals and any diagnostic tools incidental to the installation. These items will become the sole property of The Ohio State University and are not subject to any manufacturer's restrictions. Repair parts catalogs, instruction manuals, and lubrication charts will also be furnished and updated periodically with new edition publications. Furnish required verbal and written instructions to designated University personnel to allow maintenance by

**14 20 00. ELEVATORS (Cont'd)**

14 20 01. GENERAL REQUIREMENTS: (Cont'd)

university staff, following commencement of the warranty period. Notice of inspection will be given to the Physical Facilities staff so that personnel of the University may be present.

.3 PERMITS: Elevator Contractor Company shall obtain and pay for all inspection for new and modernization permits.

14 20 02. REQUIREMENTS: Elevator Design and Installation shall comply with the current Ohio Elevator Code, Escalators Code and all referenced national codes.

.1 Provide a fixed metal ladder in each hoistway pit with a light switch, a separate GFI duplex outlet in addition to a dedicated non-GFI for the sump pump, and elevator stop switch inside the entrance area.

.2 Sump pumps, or drains in the pit are required. If a sump pump is installed on a hydraulic elevator, it must pump into an oil separator/collector sized for worst case scenario; check current version of OBC. Provide removable flush grate covers on sump pump holes.

.3 Provide hoistway vents for elevators serving more than three stories. Design with vents facing in a direction protected from the primary inclement weather conditions. Vent requirement shall be per the current Ohio code.

.4 Provide an ample equipment room with heating and cooling of elevator machinery spaces. Design a machine room with an air conditioning and/or heating unit to eliminate the effects of temperature and humidity on the electronic components. The elevator machine room temperature must be maintained between 60° and 90° Fahrenheit and 40% to 75% relative humidity. The air conditioner cannot be located directly over the elevator controller. There must be at least 7' headroom. A means to collect and drain condensation shall be provided. Drains cannot be hooked directly into sewers. Provide a safe way to service air conditioners in machine room. All exposed drives must be guarded. The Elevator Machine room ventilation equipment is a vital part of the elevator operation, it is therefore, required that the Elevator and Machine Room be connected to standby power or emergency generator, if available, for reliability.

.5 Only equipment required for elevator operation is permitted in elevator equipment spaces. No extraneous piping, ductwork, conduits, etc. will be permitted in elevator equipment spaces. Elevator machine room must be equipped with a light and duplex receptacle with GFI. It must be on a separate circuit from the control equipment.

.6 Provide proper separation between equipment room and hoistway. Provide fire rated enclosure for equipment room. Hydraulic elevator machine rooms should not be located next to classroom without sound deadening material.

.7 Provide a tank heater or viscosity control monitor for hydraulic elevator oil systems. Oil tank heaters shall be large enough to maintain freely flowing oil in the coldest seasonal conditions. Low oil control monitoring is also available.

.8 If not served by an emergency supply source, all hydraulic elevators should be designed with a feature to lower the elevator to the main landing in case of a power failure, generically called an Emergency Return Unit (ERU).

**14 20 00. ELEVATORS (Cont'd)**

14 20 02. REQUIREMENTS: (Cont'd)

- .9 Provide a well casing with a plugged bottom sleeved with scheduled 40 PVC or HDPE with an end cap for further protection for all hydraulic elevators, except holeless hydraulic elevators. In addition to the sleeved well casing, the cylinder shall be wrapped with Mylar tape or coated with asphaltic application.
- .10 Comply with fire detection/alarm system code. All elevator installations must have fire fighters service, Phase 1 and 2.
- .11 Provide signs for firefighters' operation at first floor and occupants signage at each floor with a etched graphic that says "Do not use elevator in case of fire" per elevator code.
- .12 Design the elevator main floor entrance with room for passengers to wait for the elevator out of the building traffic flow. If the Elevators open into Fire resistance rated corridor (egress path) there shall be a lobby that completely separates elevators from the corridor by fire barriers and opening protection. It shall be a violation to have Elevators situated in a common shaft enclosure with stairway.
- .13 Design temperature and humidity conditioned airflow in front of the elevator doors.
- .14 Design adequate space between the elevator and the outside to allow moisture and dirt walk-off prior to elevator entry.
- .15 Design at least one elevator in each building to serve the mechanical equipment floor(s) of the building.
- .16 In multiple elevator machine rooms every elevator must be assigned a different number. The number shall be securely attached or painted on:
1. The driving machine,
  2. The main line disconnect switch,
  3. The cross head and,
  4. On the Car operation Panel.
  5. Car Light Disconnect
  6. Car HVAC Equipment Disconnect

14 20 03. GENERAL DESIGN AND PLANNING:

- .1 All components of the elevator system shall be manufactured and installed by the elevator manufacturer or by firms regularly engaged in the manufacturer of elevator components.
- .2 PREFERRED TYPE: Traction type elevators are preferred. Hydraulic elevators may be used for two, three, and four stop elevators with normal heights and light traffic loads, up to 5000 lbs. Total elevator rise not to exceed fifty feet. Holeless type elevators are acceptable, but are not to exceed 20 feet. Type required for particular project will be determined at the planning conference. Wheelchair lifts and inclining stair lifts should be avoided in preference to a holeless hydraulic elevator.
- .3 PROVISIONS FOR ADDITIONAL ELEVATORS WITHIN THE CURRENT STRUCTURE: Where multiple elevators are planned and some units are for future installation, or are specified as an alternate, group units together that are included in the base contract, with no vacant spaces between units. Provide hoisting beam in base contract for all future or alternate elevators.

**14 20 00. ELEVATORS (Cont'd)**

14 20 03. GENERAL DESIGN AND PLANNING: (Cont'd)

.4 DESIGN FOR MAXIMUM EFFICIENCY:

.4.1 Arrange equipment to provide ample room for servicing and maintenance. Design hydraulic elevator mechanical room off a public area. The hydraulic mechanical room should not share a common wall with classrooms or offices. Design traction machine room to be accessible from a public corridor. The entrance should not be accessed through an office or restroom. Locate traction machines as follows:

.4.1.1 Basement Traction Machine: Applications with heavy loads both weight and traffic count, which require a low building profile and minimized elevator overhead heights.

.4.1.2 Overhead Traction Machine: Applications over four stops. Rise, speed, and heavy weight/traffic count, will dictate geared or gearless applications.

.4.2 Select equipment with regard to function and proper size to avoid excessive wear and provide long cable life. Locate hoisting machine and sheaves to avoid reverse bends in hoist cables.

.5 SPECIFICATIONS: Including the following:

.5.1 ACCESS TO OVERHEAD SHEAVES for the lubrication and servicing. Specify cable self-oilers for traction elevators.

.5.2 All rotating equipment must be mounted on isolation pads.

.5.3 INSTALL ELECTRIC FEEDER PROTECTION including line filters with elevator controls.

.5.4 EMERGENCY OPERATION - When specified, all elevators in a bank should be sequenced to return to the main lobby, park with doors open. The next car would do the same automatically until the last car is landed at the lobby. A secondary landing would be designated by the fire system in case of fire at the lobby level.

.5.5 SEPARATE ELECTRIC SERVICE TO CONTROL SYSTEM by fused disconnect. Elevator lights and accessories will be on a separate fused disconnect and readily available to inside the door of the mechanical room.

.5.6 HOOKS AND PROTECTIVE PADS: Provide pad hooks in all elevator cabs and one set of typical protective pads per project.

.5.7 On both new and remodeling installations, premium quality heavy duty door operators and track assemblies shall be specified to provide high performance operation.

TRACKS AND ROLLER GUIDES: All tracks shall be steel. All roller guides shall consist of three sound reducing wheels and shall be precision type ball bearing steel with Durabond polyurethane tires. Roller guides shall be held in contact with the rail by means of adjustable devices. Roller guides shall run on dry unlubricated guide rails. Car rollers shall be a minimum of six inches in diameter. Counterweight rollers shall be a minimum of three inches in diameter. Elevator car doors are to be

**14 20 00. ELEVATORS (Cont'd)**

14 20 03. GENERAL DESIGN AND PLANNING: (Cont'd)

protected by full door infrared reversal devices with multiple beams that cover at least every six inch area of the opening.

- .5.8 GUARDS FOR TOP OF CAR: Where there is more than 12" of space between the car and the hoistway wall a 42" car top guard rail will be installed.
- .5.9 STAINLESS STEEL CAR DOOR and frames.
- .5.10 CEILING PANELS: Various types will be required depending on location. Type required for any location will be determined during planning conferences.
- .5.11 CAR POSITION INDICATOR: Installed at Main lobby floor.
- .5.12 FACTORY FINISHED HALL DOORS AND FRAMES: Color shall be selected by the Associate and approved by the University Architect.
- .5.13 Flooring: Subfloor and flooring usually found in Division 09. Preference should be for sheet vinyl, second for vinyl tile, and third, for carpet.
- .5.14 TELEPHONE SYSTEM: Furnish a vandal proof telephone surface mount model HFF 1 Rd by Electronic Micro Systems or equivalent. Phone must be single button operation with ring down. No phone cabinets will be allowed. The phone button should not be hooked to the alarm bell. (The phone wire to the elevator machine room will be a part of the electrical contract). It is required that each car shall be equipped with an independent phone line.
  - .5.14.1 Conduit and wiring from the Elevator Controller to the telephone backboard will be installed by the Electrical Contractor.
  - .5.14.2 Final connections to be by the Elevator Contractor.
  - .5.14.3 The elevator contractor must provide at least two pair of shielded wires (one to be a spare) for phone operation inside the travel cord.
  - .5.14.4 Connect to the Campus telephone system for a fully functional system. Follow UNITS guidelines to make the final termination to the telephone backboard.
- .5.15 The following requirements shall be covered in The Elevator's Specifications:
  - .5.15.1 Interior car finishes (Walls, Handrails, Kick Plates, etc.)
  - .5.15.2 In Car Lighting (Normal and Emergency)
  - .5.15.3 Pit Lighting
  - .5.15.4 Machine Room Lighting
  - .5.15.5 Fixture Finishes (Stainless Steel, Vandal-Proof)
  - .5.15.6 Operating Panel Requirements
  - .5.15.7 Posting of Operating Certificate
  - .5.15.8 Emergency Battery Type
  - .5.15.9 Car Top Inspection Station
  - .5.16.10 Car Ventilation

**14 20 00. ELEVATORS (Cont'd)**

14 20 03. GENERAL DESIGN AND PLANNING: (Cont'd)

.6 OPERATION:

- .6.1 CONTROLS FOR PERSONS WITH DISABILITIES: refer to ADAAG for specifics.
- .6.2 INDEPENDENT KEY CONTROL: Where elevators require key control, locked cabinets are preferred to key switches. Security issues should be addressed thru programmable software. Cylinders for key operated devices shall be specified in the section entitled FINISH HARDWARE. Final keying will be determined by the University.
- .6.3 HYDRAULIC AND ELECTRIC TRACTION ELEVATORS. The controllers shall utilize microprocessor based logic with control parameters fully field adjustable. Programmable chips shall be permanently programmed and shall not be affected by the loss of power or by spikes in the power system. The controller shall control the motor speed throughout the acceleration and deceleration to provide good floor approach and consistent stopping accuracy within 1/4" (inch). Controller shall control the high speed of the motor such that the performance time for up and down direction shall be similar. The controller's design shall be capable of controlling existing AC motors and/or new AC motors to provide the required RPM for the specified speed of the elevator. Controller shall maximize the use of solid state devices for reliability. Controller shall also provide for motor overload and overcurrent protection. The controllers shall be non-proprietary. Controllers that require special diagnostic tools/devices are prohibited.
  - .6.3.1 SPECIAL REQUIREMENT:

Specify as SAFETY MEASURE FOR TRACTION ELEVATORS, to be part of controller package, a circuit designed to detect the failure of the brake to lift. Detection of this failure shall be by means of mechanical switch and shall take the elevator out of service at the next stop and shall remain out of service until the condition is rectified.
- .6.4 Design solid state devices (SCR Drive) to reduce harmonic distortion to an acceptable level as described below.
  - .6.4.1 SCR Drive shall limit the total harmonic distortion, especially (THD) reflected back into the power system at motor speed of 50 to 100 percent (%) of without substantial harmonic distortion anywhere in the system.
  - .6.4.2 Solid state devices or SCR Drive input voltage wave form or voltage distortion limits, shall be less than 3% THD.
  - .6.4.3 Wave form distortion of the fundamental cycle can come from many sources (i.e. rotating machines, etc.). Therefore, it is required that contractor measure reflected third harmonics (THD) after the start up of the system. Contractor shall provide all the necessary instruments or tools required to accomplish this measurement without any additional cost to the University. This measurement shall be done in the presence of OSU Representative(s) from the Department of Physical Facilities, (Elevator Maintenance/Fire Protection Shop).
- .6.5 ELECTRICAL MAGNETIC FIELD INTERFERENCE (EMF) SHIELDING:
  - .6.5.1 GENERAL: Whenever elevator machine rooms/control rooms are adjacent to sensitive electrical equipment rooms (i.e. computer centers/rooms, elevator electronic control rooms) it is required that adjacent walls, floors or ceilings shall be shielded per Section 16300 of this standard.

**14 20 00. ELEVATORS (Cont'd)**

**14 20 04. DESIGN FOR SPECIFIC INSTALLATIONS:**

- .1 ELEVATORS FOR PARKING RAMPS AND OTHER OPEN STRUCTURES: Elevators shall be designed in a sheltered area where rain and snow can not reach any of the entrances directly. The elevator design shall provide for a protected area in front of the elevator doors to shelter people waiting for the elevator in inclement weather. Outdoor seasonal elevators shall be designed to provide removable exterior doors that will protect the elevator entrances and shaft from the penetration of water and snow. Outside doors will also eliminate off-season vandalism and increase safety from falls into the elevator shaft. Exclusion from the elevator by fencing or other method is preferred. Elevator shall be provided with:
- .1.1 HEAT AND AIR CONDITIONING IN EQUIPMENT ROOMS to accommodate equipment. Provide heat and air conditioning to maintain 60 to 90 degrees Fahrenheit and 40% to 75% relative humidity. Provide electrical heaters in hoistways to prevent condensation in the limit switches and ice in the door tracks.
  - .1.2 HEAT IN ELEVATOR CAB to meet code requirements.
  - .1.3 AN EMERGENCY CALL BELL switch shall operate a bell in an occupied space. In some instance (i.e., parking ramp) a remote bell in another building may be required.
  - .1.4 GLASS OBSERVATION ELEVATORS must have emergency power to operate a fan. Battery back-up shall be provided to maintain a minimum of four hours of exhaust fan operation.
- .2 ELEVATORS FOR MULTI-STORY BUILDINGS: In buildings requiring the use of automatic elevators, provide at least one elevator sized for evacuating people and for delivering firemen and equipment to a fire:
- .2.1 The elevator shall be a minimum distance between walls, or between wall and door excluding return panels, not less than 80 inches by 54 inches with a 42 inch side slide door to accommodate wheelchairs or an ambulance stretcher in its horizontal position.
- .3 The associate shall notify the University's Project Manager by letter prior to submission of schematic design documents for any of the following elevator types:
- 1. Glass walled observation elevators
  - 2. Outside elevators
  - 3. Outside seasonal elevators
  - 4. Open air hoistways

---

END OF DIVISION 14 – CONVEYING SYSTEMS

# FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS

2006 Edition, Published January 1, 2006; Division Revision Date: February 7, 2017

## PART FOUR DOCUMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL CONSTRUCTION

### FS-1. SEPARATE DOCUMENTS REQUIRED

- .1 THE LAW AND THE CSI FORMAT: Section 153.50 and 153.52 of the Revised Code of the State of Ohio requires that completely separate drawings and specifications be prepared for each of the following prime contracts:

General Construction Contract  
Plumbing (and Fire Protection) Contract  
Heating, Ventilating, and Air Conditioning Contract  
Electrical Contract

All work related to Fire Protection should normally be included in the scope of the Plumbing Contract. The new CSI format now makes provision for the separation of Plumbing, Fire Protection, Electrical and HVAC specifications.

- .2 SEPARATION OF PLUMBING, FIRE PROTECTION AND HVAC (HEATING, VENTILATING AND AIR CONDITIONING): The University requires that the complete separation of documents for these Divisions of The Work be made evident by prohibiting use of the word "MECHANICAL" when writing specifications for these Divisions and when making references to the contracts and contractors for any of these parts of The Work. In preparation of specifications, numbering of sections for Fire Protection shall be preceded by "21", Plumbing by "22" and HVAC (Heating, Ventilating and Air Conditioning) by "23". Any system of numbering (either an alphanumeric system or a decimal system) may be used for the sections, articles, and paragraphs comprising these Divisions, at the Architect/Engineer's (A/E) option.

### FS-2. DESIGN CONSIDERATIONS

- .1 DIRECT DIGITAL CONTROL (DDC) AND BUILDING AUTOMATION SYSTEMS: Refer to Division 23 and Appendix A of the Building Design Standards.
- .2 AESTHETICS: Requirements for aesthetic design and for coordination of design between the A/E and each of his consultants are stipulated in PART ONE, paragraph 00021, and 00023. These requirements are repeated here for emphasis.
- .2.1 EXTERIOR INSTALLATIONS: Design for proper functions and consider in the aesthetics of building design. Large and unsightly installations shall be hidden from public view or shall be appropriately screened. If due consideration of aesthetics is not observed, the University Architect will require complete redesign of systems and of structure elevations until a pleasing, well integrated design is achieved. Elevations, site, and roof plans must show all equipment, such as fans, cooling towers, etc.
- .2.1.1 TRANSFORMER STATIONS: Wherever feasible, as determined by the location of the service entrance and the space available on the site, transformer station shall be located inside the building along the exterior wall of the building at grade level. Exterior installation shall be approved by the University Architect.



## **FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS**

---

- .2.2 INTERIOR INSTALLATIONS: The A/E shall allow sufficient room for an orderly arrangement of equipment, piping, and conduit and shall continually monitor the work of consultants to see that pleasing arrangements are achieved. Special consideration shall be given to dimensions of floor to ceiling spaces to allow for concealment of systems, as much as practicable.
- .3 FUEL OIL TANKS AND SYSTEMS: Provide heat and insulation for tanks, pumps, lines, etc. to assure cold weather operation of the equipment and systems dependent upon the fuel supply where possible locate tanks above ground in order to respond to an unexpected or accidental leak.
- .4 METERING: Separate and permanent smart meters for all utilities (gas, electric, domestic cold water, auxiliary (for example, makeup and irrigation), chilled water, and steam) shall be provided for each building. Some buildings and systems will require additional sub-metering to facilitate adjustment of charges for water supply and sewage discharged. Refer to Division 33 of the Building Design Standards for metering requirements and standards.
- .5 ALARM SYSTEMS: All Fire Alarm Systems, all HVAC systems, and all Critical Environments Systems must be provided with dry-contact relay outputs connected to the University's existing campus-wide Access Control and Alarm Monitoring System (ACAMS) see Section 28 10 00. for all requirements.

Each individual field device must be capable of individually identifying itself when in an alarm or trouble condition. All alarm and fire suppression systems must be capable of self monitoring for all appropriate status changes such as, but not limited to, system trouble, water flow, improper water or air pressure, power loss, tamper, etc.

Any status change from any alarm system must be reported via the dry-contact relay output to the campus-wide Access Control and Alarm Monitoring System (ACAMS). All alarm systems are required to have backup power supplies including 24-hours or greater of monitoring, plus 4-hours or greater of local alarming, or longer if specified differently by building code, fire code, or higher authority.

The University has standardized on a campus-wide Access Control and Alarm Monitoring System (ACAMS) based upon Lenel Systems, International, Inc., Corporate Headquarters, 1212 Pittsford-Victor Rd., Pittsford, NY 14534-3820. See Section 28 10 00 for all requirements. All Columbus Campus alarm installations which require 24-hour remote reporting and monitoring must utilize this system.

Any new card access systems will require the use of Lenel systems and Lenel-compatible card readers, all to be consistent with Division 28, Section 28 10 00., unless written authorization is received from the Associate Vice President, Facilities Operations and Development, and the Assistant Vice President, Department of Public Safety, of the Office of Business and Finance to use an alternate.

Similarly, no card access system for exterior University building doors may be purchased or installed without specific approval from the Associate Vice President, Facilities Operations and Development, and the Assistant Vice President, Department of Public Safety, of the Office of Business and Finance.

### **FS-3. COORDINATION OF CONTRACT DOCUMENTS**

- .1 CROSS REFERENCES: Refer to PART ONE, for A/E's responsibilities regarding documents prepared by consultants. Documents for each Division of the work shall be compared with each other, not only to eliminate discrepancies between documents, but also to avoid repetition of requirements that are common to two or more divisions of the work. The

## FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS

---

requirement that separate documents be prepared for each division of the work does not preclude the incorporation of provisions contained in other divisions of the specifications by reference to the particular provisions.

Specifying by reference to other divisions and sections is no different from making references to ASTM designations, Federal Specifications or manufacturer's specifications. This method of specifying certain requirements will not only reduce the volume of the specifications but will also help assure complete coordination of the documents; in addition, forcing contractors to refer to other divisions of the specifications will serve as a reminder that their parts of the work must be integrated with other parts. Procedural, administrative, temporary facility and similar information belongs in Division 1. Do not duplicate such information in Division 21, 22, 23 or 26. Simply refer to Division 1 for such information. Examples of provisions that should be specified follow; this list is not all-inclusive.

- .2 CUTTING AND PATCHING: Division 1 should contain the article covering this item of work; however, mention should be made of special items of work that are not adequately covered in the General Conditions. Clearly indicate that responsibility and cost is to be borne by the contractor for the particular division.
- .3 TEMPORARY FACILITIES: Make reference to applicable portions of Division 1 (Section 01 50 00. to 01 60 00.) and Special Conditions. See State Architect's Handbook.
- .4 UTILITY CONNECTIONS: Include the following instructions in the specifications:

"Procedure for making connections to existing utilities shall be planned at least two weeks in advance of the work and the work shall be executed in a manner to provide reasonably continuous service throughout the construction period. **Connections shall be made only at times approved by the University Construction Manager.** For interruption of service in major utility systems, the Contractor must submit to the A/E a step-by-step sequence of operations planned to accomplish the work. Outline must show tentative dates and times of day for shut-off and restoration of services."

The A/E will review the information given with the University Construction Manager, who, upon approval of the planned operations, will make arrangements with appropriate University personnel for interruption of services. Refer to Division 01 of the Building Design Standards. The A/E shall also specify and refer to the OSU Utility Outage Procedure found on FOD's website under the Vendor Resources, Utilities tabs with the following link: <https://fod.osu.edu/resources>.

**Caution to Bidders: Bidders are cautioned that the University will probably schedule interruption of services at times other than the contractors' normal working hours and that only designated University personnel are authorized to interrupt services.** Frequently, outages are scheduled between quarters to reduce disruption of classes.

- .5 USE OF PREMISES: Make reference to the applicable portions of Division 1. If routing of trucks hauling materials to and from the site cannot be adequately described in the specifications, show routes on the Location Plan.
  - .5.1 While the Ohio State University is a publicly owned institution, its facilities are dedicated to serve specific functions, operations, and programs. Therefore, contractors' personnel may be barred from using existing toilets, food service, or other facilities.

## FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS

---

- .5.2 Show on plans the staging areas, material storage areas, office trailer locations, ingress routes, site limitations, etc., as required to convey opportunities and restrictions to the contractors.
- .6 PERMANENT UTILITY CONNECTIONS: On projects where connections to existing utilities (i.e., steam, condensate return, hot water heating, hot water return, chilled water, chilled water return, domestic hot water, gas, cold water, alarm systems, emergency electric, electric, etc.) are proposed, the A/E shall contact Facilities Operations and Development (through the University Engineer) to ascertain the actual operating conditions and limitations of such systems to confirm that ample capacity, both present and future, will be available for project loads. The A/E shall also complete and submit for approval the Utilities Request Form found on the FOD website at <http://fod.osu.edu/resources>. The A/E shall submit proposed modifications to the University's utility connection requirements to the University Engineer for prior approval. This is mandatory in order to obtain approval for connection and/or extension of any utilities. Instructions in the specifications (similar to those defined in Paragraph FS-3.4. above) must be provided to insure proper bidding, planning, coordination and minimal utility outages. Also see Division 33, Utilities.
- .7 UNDERGROUND PIPING: Where practicable, underground piping (particularly steam lines), shall be routed to pass underneath walks or other paved areas in order to protect planted areas from the heat transmitted by such piping.
- .8 MANHOLES: Refer to City of Columbus, Ohio, Standard Construction Drawings.
- .9 EXCAVATION AND BACKFILL: Specifications shall clearly define responsibilities of each contractor involved. Materials and compaction of backfill materials must be coordinated with requirements stated in Division 2 of these guides. **Note that the use of grits for backfill is prohibited.**
- .10 CONCRETE PADS, BASES, AND CURBS: In Division 21, 22, 23, and 26, call attention to the fact that concrete pads, bases, and curbs are provided in Division 3; however, the Plumbing, HVAC, Fire Protection, and Electrical Contractors shall furnish and install sleeves, anchors, and other items which require embedment in concrete. These installations must be coordinated with the work specified to be performed by the General Contractor.
  - .10.1 CURBS: Duct spaces, pipe shafts, and similar openings in slabs shall be curbed in HVAC equipment rooms, pump rooms, kitchens, and other areas which are subject to flooding. Curbs shall be not less than 4 inches high. The General Contract drawings shall show required curbs.
- .11 PENETRATION OF FLOORS AND OF FIRE RATED WALLS by pipes, ducts, cabinets, etc. is prohibited, unless openings are appropriately fire-stopped by fire dampers, or sealing of voids with fireproof materials. Fire-rated walls or floors must not have the rating reduced by penetrations or reduction of thickness. Precautions must be used by contractors when coring or making penetrations to ensure that the cored material does not drop to the floor below and cause an accident or injury.
- .12 SLEEVES for copper pipe shall be fabricated of copper pipe for up to 4 inches in diameter.
  - .12.1 PROTECTION FOR INSULATED PIPES: When insulated pipes penetrate floors that will be covered with finish flooring, specify that a sheet metal protective covering be installed around the insulation jacket. Sheet metal jacket shall extend through and above the pipe sleeve far enough to protect the insulation from bumping by floor polishing machines and vacuum sweepers. Space between the pipe sleeve and the sheet metal must be sealed. Where insulated pipes pass through wall sleeves, cover

## FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS

---

- insulation with sheet metal and seal both ends of the space between the sleeve and sheet metal with non-combustible packing.
- .12.2 CLEARANCE: Provide not less than 1/4 inch clearance on all sides for both insulated and non-insulated pipes which penetrate walls and slabs.
- .12.3 LENGTHS: Except where greater lengths are required for penetrations through floors, sleeves shall be fabricated to a length equal to the thickness of construction through which they pass. See below.
- .12.3.1 SLEEVES THROUGH WATERPROOFED FLOORS shall project a minimum of 4-inches above the floor.
- .12.3.2 SLEEVES IN HVAC AND PLUMBING EQUIPMENT ROOMS shall extend no less than 1-1/4 inches above the curbs.
- .12.3.3 SLEEVES IN ALL OTHER FLOORS shall extend 3/4 inch above the finish material on the floor.
- .12.3.4 SEALS: Special wall sleeve fittings with soft rubber seals shall be specified for water service piping. In other installations, the void between pipe and sleeve shall be sealed with mineral wool or other non-combustible material to prevent passage of flame and smoke. In locations exposed to public view, the packing materials shall be concealed with sheet metal cover plates or split type, chromium plated brass escutcheons.
- .12.4 FIRE-STOPPING: Specify and show fire stopping at all penetrations of fire-rated assemblies.
- .13 MASONRY STRUCTURES: If these structures are not provided in the General Contract, materials and installation should be specified by reference to applicable portions of Division 4. If installation details differ from installation specified in Division 4, specify the special requirements.
- .14 STRUCTURAL SYSTEMS: Lintels for openings to accommodate plumbing, HVAC, fire protection, and electrical installations should be provided in Division 5. Refer to paragraph 05 50 00. Any other structural steel required for support of equipment can be specified by making reference to applicable portions of Division 5.
- .15 ANCHORAGES AND SUSPENSION SYSTEMS: Ceiling grid systems shall not be supported from ductwork, electrical conduit, heating or plumbing lines, and vice versa. Each utility system and the ceiling grid system shall be a separate installation and each shall be independently supported from the building structure. Where interference occurs, provide trapeze type hangers or other suitable supports for each system. Locate hangers and supports where they will not interfere with access to mixing boxes, fire dampers, valves, and other appurtenances requiring servicing. Attention to this prohibition must be included in every section when there is the possibility that other than the independent suspensions systems would be used, together with prohibitions against use of perforated steel strap, power actuated anchors and plug anchorage (using wood, lead or plastic).
- .16 ROOF MOUNTED EQUIPMENT, FLASHING AND ROOF PENETRATIONS: Specifications should alert the Plumbing, HVAC, Fire Protection and Electric Contractors that installation must be coordinated with work specified to be performed by the roofer. Refer to paragraphs 07 50 10.3 and 07 60 10.4. All roof mounted equipment (i.e., heating, air conditioning, exhaust fans, intakes, etc.) shall be provided with pre-fabricated mounting curbs at least 12-inches high. Curb shall be fabricated of double dipped galvanized steel, copper or stainless steel. Any installation design must facilitate roof repair and maintenance. Protrusions through roof (ducts,

**FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS**

---

pipe clusters, etc.) shall be located go as not to disrupt flow of water to roof drain. Maintain a minimum clearance of 6-feet from parapet walls or change in elevation and from roof sumps or drains. Note that pitch pans or pitch pockets are prohibited. Additionally, establish architectural acceptability with only projections approved by the Project Manager.

- .17 PAINTING: Cleaning and painting of Plumbing, HVAC, Fire Protection, and Electrical items and equipment exposed to view should be specified in Division 9. If concealed installations require painting before being concealed, list the installations and specify that materials and application be as specified in Division 9. Do not specify painting of the same surface under more than one Division except shop prime coats, where protection is needed, color banding and flow arrows. See 09 91 23.1.

USE OF INK MARKING PENS ON ANY SURFACE IS PROHIBITED. Marks bleed through paint or other finishes.

- .17.1 COLOR CODING OF PIPING: Specify that, after piping has been finish painted, the installer of the piping identify the type of service lines with applied color bands and stenciled letters and indicate direction of flow with stenciled arrows. Color bands shall be 1-inch wide, finished in gloss enamel; lettering and arrows shall be same color as the bands. Specify that indicators be applied at connections to pumps, chillers, and other equipment; at entrances to spaces; adjacent to valves; near access doors to pipe spaces; and at 30-foot maximum intervals on long pipe runs. Specify that letters be positioned to be easily read from a normal standing position.

.17.1.1 Use the following band colors and letter designations:

<b>Type of Service</b>	<b>Color</b>	<b>Designation</b>
PLUMBING PIPING (Show direction of flow)		
Compressed Air	White	CA
Drain	Room Color	
Natural Gas	Yellow	Gas
Hydrogen	Red	HYD
Nitrogen	Black	NIT
Oxygen	Green	OXY
Vacuum	Room Color	VAC
Domestic Cold Water	Light Blue	DCWS
Domestic Hot Water	Dark Blue	DHWS
Domestic Hot Water Return	Dark Blue	DHWR
Deionized Water	Room Color	DZDW
Distilled Water	Room Color	DSTLW
Soft Water	Medium Blue	SFTW
Oil, Fuel, or Hydraulic	Orange	Oil
HEATING AND COOLING PIPING (Show direction of flow)		
High Pressure Steam 125PSI	Aluminum/Orange Band	HPS
Med. Pressure Steam 50PSI	Aluminum	MPS
Low Pressure Steam 15PSI	Aluminum	LPS
Boiler Feed Water	Green	BLR F
Chilled Water Supply	Black	CWS
Chilled Water Return	Black	CWR
Condensate Water	Aluminum	COND
Condenser Water	Purple	CDSR
Hot Water Heating Supply	Lime Green	HWHS
Hot Water Heating Return	Lime Green	HWHR



**FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS**

---

	10	22
	12	23
<b>Copper</b>		
	1/2	6
	3/4 to 1	7
	1-1/4 to 2	9
	2-1/2 to 5	11
	6 to 8	14

FOR CAST IRON, BELL, AND SPIGOT PIPING, space supports at 5 ft. o.c., maximum.

SOIL PIPE shall be supported at each floor on (vertical stacks), and at each 5 ft. increment, joint, and elsewhere as required for adequate support.

- .19.3 **THREADING** cast iron or ductile iron pipe is prohibited. Call attention to this in applicable specification sections.
  
- .20 **MOTORIZED EQUIPMENT:** Basic requirements for electrical work and equipment are covered in Division 26 of these standards. The requirements included herein cover specific items that have been troublesome in the past and require that the specifications incorporate adequate provisions for electrical work and equipment furnished by the Plumbing, HVAC, and Fire Protection Contractors. The A/E shall specify motors, drives, and equipment to meet all operating requirements for the installation. Consideration for motors should be for voltage, phase, frequency, frame size, temperature rise, and sufficient starting torque to start loads with high inertia. Performance requirements should include capability to make multiple starts per day to meet energy conservation control requirements. Where necessary, non-recycling shall be specified to protect the equipment from short time recycling.
  - .20.1 **WIRING:** Specifications shall clearly point out the responsibility for wiring related to Plumbing, HVAC and Fire Protection equipment. In general, it is required that power wiring is provided by the Electrical Contractor and control wiring is provided by the Plumbing, HVAC and Fire Protection Contractor. Also see Communications Wiring Standard in Appendix.
  - .20.2 **STARTERS:** Specifications shall require that motor starters be provided by the Electrical Contractor. Exceptions to this requirement will require the approval of the A/E and his review is necessary to ascertain that standards stipulated in the electrical specifications are followed.
  - .20.3 **MOTORS** shall be sized in accordance with applicable NEMA standards for the operating conditions of each specific items of equipment with a 1.5 service factor. Motors must be selected to operate within nameplate Hp and shall not operate on the service factor. Short shaft motors shall not be used for belt drives. In general, motors one-half horsepower or smaller shall be single phase; larger motors shall be three phase. Motors shall be provided with electrical overload protection to prevent burn-out under operating conditions. Large motors shall have adequate internal overload and thermal protection in addition to the overload elements in the motor starter.

**FS-4. CONSTRUCTION PHASE SUBMITTALS**

- .1 **GENERAL:** Refer to Division 1 for the list of submittals required to insure quality control of materials and workmanship. Submittals required for specific items may be stipulated in articles in which the items are specified (as is done in these guides), or may be listed under this heading. The A/E shall stipulate additional submittals that he deems necessary for the prosecution of the work.

## **FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS**

---

- .2 SAMPLES AND SHOP DRAWINGS: Reference should be made to Division 1 for instructions for making these submittals. In Divisions 21, 22, 23, 26, 27, and 28, only a listing, of items for which samples and drawings are required, will suffice.
- .2.1 Submittals shall be specified to be provided within 90-days of Notification to Proceed.
- .2.2 PERFORMANCE CURVES: Specify that these be submitted with shop drawings.
- .3 RECORD DRAWINGS: The A/E is directly responsible for the accuracy of these records. In addition to notes made in the field by the A/E's representative, Article 11 of the General Conditions requires Division Contractors to accurately record all deviations from Contract Documents during construction and to furnish this information to the A/E. When writing specifications, avoid wording that might suggest to contractors that changes can be made without prior approval. See 01 78 39.2.
- .3.1 Building Information Modeling (BIM): The Architect/Engineer, or Contractor shall meet, for projects four million dollars or greater, the BIM Project Delivery Standards (BIM PDS).
- .4 WARRANTIES, OPERATION AND MAINTENANCE MANUALS: At the time of Beneficial Occupancy of the project, four approved copies of warranties, instruction sheets, catalogue data, and final shop drawings secured in binders shall be forwarded to the University Engineer. Also see 01 78 23. Provide full information (trim sheets and log sheets) defining all conditions, quantities of refrigerant, pressures, temperatures, etc. during the testing operations of each piece of equipment.
- .5 POWER AND CONTROL DRAWINGS: Electrical power and control drawings for large, complex electrical equipment shall be supplied and posted at, on, or near the equipment. Provide framed glass or plastic protection.
- .6 DIAGRAMS AND OPERATING INSTRUCTIONS: Complete diagrams and operating instructions for all control systems shall be posted near the related equipment. Provide framed glass or plastic protection. When multiple equipment rooms exist in a building, these diagrams will be required at each piece of equipment. Additionally, a complete set of diagrams will be posted or made available in the main equipment room.

### **FS-5. SAFETY REQUIREMENTS**

- .1 OSHA REQUIREMENTS: Belt guards, coupling guards, rails, and other protective devices shall be provided to meet OSHA requirements and Ohio Industrial Commission.
- .2 Contractor shall be required to comply with all requirements for Material Safety Data Sheets (MSDS's), lockout and tagout procedures, confined space entry requirements, hot work permits, construction site fire protection, fall protection for all contractor and subcontractor employees, hazardous materials abatement procedures, prohibition of mercury-containing materials, etc.

### **FS-6. A REVIEW OF ENERGY CONSERVATION REQUIREMENTS**

The subject of energy conservation is discussed in various sections of these BUILDING DESIGN STANDARDS. This review is made for the purpose of consolidating all requirements for this important part of design under one heading for easy reference.

- .1 GENERAL REQUIREMENTS



## FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS

---

.1.1 The University is dedicated to the principle of conserving energy and will scrutinize proposed construction for means of reducing not only initial cost, but also long-range operating costs. The A/E must work in close cooperation with his consultants to design new buildings and remodel existing buildings making the most efficient use of building materials and energy sources available. Energy Conservation is dependent on all elements of a total building structure. Compliance with the OSU **Green Build and Energy Policy 3.10** is mandatory. If, in Schematic or Design Development submittals, it is determined that the project does not meet or exceed the requirements of OSU Policy 3.10, a conference with The University Engineer will be required to determine the course of action. Redesign of problematic portions of the building will be required with all professionals working in close cooperation to design energy efficient buildings. Refer to Part 1, "The Design Process" of the BDS for the required design documentation submittals to show compliance with OSU Policy 3.10.

.1.2 In the design of the HVAC and Electrical systems, consideration must be given to building utilization by planning for conservation of energy during summer and winter vacations and for other periods of minimum occupancy. Research laboratories, spaces for animals, server rooms, communications rooms, IDF's, MDF's, and other spaces which might require 24 hours/day operation must be serviced by systems separate from office systems which may require only 8 hours/day operation, and classrooms which may be shut down during summer and vacation periods.

.1.3 The capability of using alternate sources of energy is of extreme importance. If gas-fired boilers are installed, the facilities must be provided with stand-by equipment for use of other fuels or sources of energy.

### .2 BUILDING CONSTRUCTION REQUIREMENTS

.2.1 The exterior envelope shall be given careful consideration. University maintenance, security, and utility costs indicate the need for restraint in the use of large areas of glass. If large areas of glass are required for aesthetics, careful orientation of these areas for reduction of heat loss and heat gain must be made.

.2.2 WINDOWS, insofar as practicable, shall be provided with operable vent sections.

.2.3 The overall R-Value of walls, including windows and doors, shall be consistent with, and more energy efficient than, the code requirements of the Ohio Building Code.

.2.4 The overall ceiling and roof R-Value shall be consistent with, and more energy efficient than, the code requirements of the Ohio Building Code.

.2.5 INFILTRATION shall be consistent with, and more energy efficient than, the code requirements of the Ohio Building Code. Compliance with the overall air leakage requirement should be determined by calculations using certified data furnished by the manufacturers or suppliers for doors, windows, and wall materials supplemented by calculations using the crack method given in the ASHRAE Handbook of Fundamentals at the appropriate prevailing design wind condition for the area of application.

### .3 BUILDING SYSTEMS - DESIGN REQUIREMENTS

.3.1 HVAC systems, lighting systems, building envelopes and other building energy consuming systems shall be designed to conserve energy. Replacement of air handling units, lighting systems, or other systems utilizing energy, directly or indirectly, shall be treated as new systems and not as repair or maintenance. Therefore, new systems must comply with the OSU Green Build and Energy Policy 3.10.

## FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS

---

- .3.2 Design temperatures for heating and air conditioning systems shall be as follows:

Summer: Outside conditions, 92 degrees FDB and 74 degrees FWB  
Inside conditions, 76 degrees FDB and 64 degrees FWB

Winter for space conditioning:

Winter: Outside conditions, +1 degrees FDB  
Inside conditions, 70 degrees FDB

Winter for preheat coil sizing on 100% outdoor air fan systems:

Winter: Outside conditions, (minus) -22 degrees FDB  
Coil Leaving Air conditions, +55 degrees FDB

Relative humidity should range between 40 and 70 percent in order to control the growth of molds, fungi, bacteria, etc.

Special areas, such as computer rooms, animal areas, etc., will have temperature and humidity requirements transmitted to the A/E by the University Engineer.

- .3.3 Occupied-unoccupied programming of systems should be initiated to shut-off ventilation air, exhaust air, fan systems, pumps, etc., wherever possible. Where shut-down of systems cannot be accomplished during unoccupied hours, heat recovery systems should be considered. Each application should be examined independently to determine any special sources for obtaining a recovery of usable energy. An economic analysis by the A/E's consultants may be required to determine the feasibility of energy recovery systems before the University Engineer will render a decision of their acceptability. Four copies of this analysis shall be furnished by the A/E to the University Engineer.
- .3.4 Fan coil units and radiation will be required in specific areas to facilitate shut-down of major fan units. Where necessary, the controls on these units shall be coordinated with the controls on the air handling units.
- .3.5 All air conditioning systems shall have controlled economizer cycles where required by the energy code. Air conditioning systems smaller than this shall have controlled economizer cycles where the cost for additional work and equipment involved can be justified. All systems that have economizer cycles shall be capable of running the cooling equipment independent of the economizer cycle controls. Furthermore, the economizer control shall not revert to the minimum outside air damper position for cooling season unless mechanical cooling is available.
- .3.6 All air conditioning, heating, ventilating, and exhaust systems shall be closely matched to the minimum required performance. The use of variable volume supply and exhaust air systems is encouraged to compensate for diversities in loads and reduce equipment sizes. Space air outlets should be aspirating types to prevent "dumping" of air into occupied spaces.
- .3.7 Interior spaces requiring cooling the year around should be handled independently from perimeter areas requiring heating during the winter and cooling during summer. Interior areas should be supplied from a variable volume cooling system utilizing controlled economizer cycle. The perimeter systems should utilize controlled economizer cycles when cooling is required and minimum ventilation rates when heating is required.
- .3.7.1 For any system based upon variable air volume, include a pre-heat coil as the first coil in the fresh air stream, sized to preheat the fixed-minimum ventilation air from design heating outdoor air temperature up to design mixed air

## **FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS**

---

temperature. This will help to maintain the required fixed minimum ventilation air, by preventing the mixed air temperature controller from closing the outside air damper.

- .3.7.2 Apply carbon dioxide (CO<sub>2</sub>) monitors in large occupancy rooms, such as auditoria, etc., to monitor and regulate the ventilation air as required to maintain the CO<sub>2</sub> values below 1000 parts per million (ppm).
- .3.8 The following criteria shall be employed in the selection of equipment (each project to be reviewed on an individual basis):
  - .3.8.1 FANS selected for operation above 6-1/2" total static pressure must be approved by the University Engineer.
  - .3.8.2 COMPRESSORS for electricity-driven chillers and refrigeration units, Electrical power consumption shall be in compliance with Policy 3.10. Absorption water chillers should not be used unless waste heat is available. The University's central steam distribution system is NOT considered waste heat.
  - .3.8.3 Due to the highly technical nature of chiller selection as to its performance characteristics, space requirements, isolation requirements with regard to noise and vibration, and other requirements, the A/E and Facilities Operations and Development through the University Engineer will mutually designate one manufacturer to be specified as base bid. Equals will be developed for bidding two other units.
  - .3.8.4 Water-cooled, air-cooled, or evaporative condensers are acceptable depending upon job requirements and necessities. Water-type cooling towers are preferred to conserve energy and shall generally be used on systems 80-tons and larger. On units below 80-tons, an economic evaluation, including cost of maintenance should be made to determine if the condensing unit will be air cooled or water cooled.

Cooling tower fan motor loads shall not exceed 0.06 H.P./ ton of chiller capacity. Reduced condenser water temperatures should be utilized when possible to reduce the chiller electrical consumption. At design conditions air cooled condensers shall have not more than 115°F condensing temperature with 20°F temperature difference between air entering and leaving the condenser.
- .3.9 Variable Frequency Drives, elevator controllers and other electronic equipment are to be located within a separate temperature controller area of building maintenance rooms to avoid the harmful effects of heat produced by steam stations, heating hot water pumps or other building systems producing local environment which exceed safe operating conditions for electronic equipment.

### **.4 ELECTRIC LIGHTING REQUIREMENTS**

- .4.1 LIGHTING SYSTEMS should be considered as a source of heat to supplement heating requirements and recovery systems shall be provided wherever practicable.

### **FS-7. EQUIPMENT**

- .1 FIXED EQUIPMENT required by the program will be furnished by the project unless written exception is given by the University Engineer for the omission. Also, See Division 11.

## FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL DOCUMENTS

---

### .2 RELOCATING EXISTING EQUIPMENT

- .2.1 Relocation of existing equipment must include disconnecting and moving to new location as well as restoration and capping utilities at the old location.
- .2.2 Require the contractor to be responsible for recording existing wiring and piping to facilitate reinstallation.
- .2.3 Require the contractors to replace unsalvageable piping and wiring and to furnish any new piping and wiring to complete proper reinstallation.
- .3 RESTRICTED LOCATION: Operating equipment other than sump pumps shall not be located below the published 500 year FEMA floodplain elevation for hydraulically connected facilities.

**Commentary:** *"hydraulically connected" is intended to mean facilities that are connected to other buildings/facilities or the Olentangy River by tunnels, drain pipes, conduit, etc.*

END OF FACILITY SERVICES

## **DIVISION 21 – FIRE SUPPRESSION**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **21 00 00. FIRE SUPPRESSION**

#### **21 00 03. GENERAL PROVISIONS**

##### **.1 PREPARATION OF CONTRACT DOCUMENTS**

.1.1 **PLUMBING CONTRACT:** Include work related to Fire Protection within the scope of the Plumbing Contract. The Architect/Engineer shall consult with the Ohio State University's Division of Emergency Management and Fire Prevention and Facilities Design and Construction Technical Services Group during the early planning phase and prior to any meetings with the Authority Having Jurisdiction.

.1.1.1 Specify that the contractor performing the fire protection work shall be licensed and certified by the Department of Commerce Division of State Fire Marshal to perform work on the fire protection system.

.2 **NFPA:** Installation must comply with all current editions of the NFPA as referenced in the current edition of the Ohio Building Code (OBC), unless noted otherwise. Whenever referring to materials and installations by National Fire Protection Association Publications use the OBC referenced edition, unless noted otherwise, and include the date of each referenced publication in the specifications.

.3 **EXISTING FIRE PUMPS:** In remodeling or alteration projects where an existing fire pump will be used, consult the University Architect regarding desirability to updating systems to comply with the standards stipulated herein.

.4 The Architect/Engineer should note that the Department of Commerce Division of State Fire Marshal is the Authority Having Jurisdiction (AHJ) on the Columbus Campus.

#### **21 00 05. SUBMITTALS**

.1 **SUBMITTALS:** Require that shop drawings for systems be sent to the Architect/Engineer (A/E) for review and after approval be submitted by the (A/E) to the Department of Commerce Division of State Fire Marshal for review. Require that informational and/or operating manuals be provided for all fire protection equipment.

.1.1 List of required submittals shall include backflow preventers, fire pump, fire pump controller, jockey pump, piping, pipe fittings, sprinkler heads, flow switches, tamper switches, any additional required submittals shall also be provided.

.1.2 Specify three unique stages of design submittals for any fire suppression system, as follows:

.1.2.1 **Materials and Equipment List:** Include all materials, equipment and accessories required for the work. Include catalog ID numbers, drawings, cut sheets as necessary to define the work. If cut sheets include multiple selections, and or optional selections, then clearly label the included selections and the included options. Submit to the Architect/Engineer (A/E) for review.

.1.2.2 **Preliminary Shop Drawings:** Include sprinkler head locations only. Include full-size detail representation of each style of sprinkler head to be used. Submit to the Architect/Engineer (A/E) for review.

## **DIVISION 21 – FIRE SUPPRESSION**

---

.1.2.3 Detailed Shop Drawings: Include pipe layout and sizing, sprinkler head locations coordinated onto reflected ceiling drawings, hydraulic calculations, system controls, and all equipment cut sheets, zone valves, zone drain valves, and zone test stations. Submit to the Architect/Engineer (A/E) who, after review and approval, shall submit to all required parties identified in 21 00 05, Authority Having Jurisdiction (AHJ), the Department of Commerce Division of State Fire Marshal, and the University's Office of Financial Services Insurance Administrator, for review and approval by all.

### **21 00 07. TESTING**

.1 TESTING OF FIRE PUMPS: Include in the specifications the requirement that the contractor and the pump manufacturer perform an acceptance test of the system in the presence of the A/E and designated University personnel. Prior to the acceptance test, the fire pump will be tested for proper operation. Scheduling and other arrangements for the demonstration shall be made through the A/E and the University Project Representative.

### **21 00 09. RELATED WORK IN GENERAL CONSTRUCTION**

.1 FIRE EXTINGUISHERS AND NON-VALVED CABINETS: Specify these in Division 10 SPECIALTIES as part of the General Contract.

.2 FIRE CABINETS shall include fire department standpipe valve connection, fire extinguishers, and space for them. Make certain that extinguisher is specified in General Contract Division 10.

### **21 05 05. FIRE SUPPRESSION MATERIALS AND METHODS**

#### **21 05 25. VALVES**

.1 GATE VALVES: Use UL approved O.S.& Y., 175 lb., except hose cabinet valves.

.1.1 2-1/2 in and smaller, brass or bronze body, trim and stem, solid wedge, rising stem, union bonnet, screwed or flanged ends.

.1.2 3 in. and larger, iron body, bronze trimmed, O.S.& Y., flanged ends.

.1.3 All post indicating valves located in areas subject to damage by vehicular traffic shall be protected by bollards.

### **21 10 00. WATER-BASED FIRE SUPPRESSION SYSTEMS**

#### **21 11 16. FACILITY FIRE HYDRANTS**

.1 SCOPE OF WORK: The Contractor shall furnish all labor, tools, material and equipment necessary to furnish and install new fire hydrants at the locations shown on the plans or as ordered and specified.

.1.1 Architect/Engineer (A/E) shall require the Contractor to include all excavation, furnishing and installing the new fire hydrant complete with proper jointing, blocking, backfilling, and all other incidental work necessary to complete this item of work. Hydrant watch valves and 6 inch ductile iron hydrant leads are to be installed where necessary.

## DIVISION 21 – FIRE SUPPRESSION

---

- .1.2 Remove the existing hydrants, any shut-off (auxiliary) valves (when necessary) and associated piping. Do not remove shut-off valves that are more than five feet from the hydrants they serve, that are in roads.
  - .1.3 Remove the lengths of piping necessary to maintain five feet maximum depth at the auxiliary valves and hydrant bases.
  - .1.4 Architect/Engineer (A/E) shall require the Contractor to be responsible for backfilling to the extent required to accomplish the required testing, providing suitable barricades around openings and providing the A/E and the University Project Representative a schedule of when the various hydrants are ready for inspection, testing, and site restoration.
  - .1.5 **Architect/Engineer (A/E) shall require the Contractor to notify Facilities Operations and Development's (FOD's) Manager of Utility Services (614-292-6383) no less than ten working days prior to taking any fire hydrant out of service.**
- .2 ALL FIRE HYDRANTS shall be post type made of cast iron and shall conform in all respects to the American Water Works Association Standard for "Fire Hydrants for Ordinary Water Works Service", AWWA - C502-80 except as herein after specified.
- .2.1 Type of Hydrant: Fire hydrants shall be Clow-Eddy model F-2640 break flange/compression type (AWWA C502-80) with 7/8-inch tapered to 1-inch operating nut (turning clockwise to open and counter-clockwise to close), rising center stem, safety coupling, compression type valve, 4-1/2 inch minimum valve opening, factory sealed drain opening, and a 4-inch pumper nozzle. Nozzle thread and finish shall comply with local fire department's standards. Hydrant shall be designed for 150 pounds working pressure and tested to 200 pounds hydrostatic pressure. Hydrants inlet connection shall be 6-inch mechanical joint type.
  - .2.2 Valves: Auxiliary shut-off valves shall be Clow #F-5065 with mechanical joints, cast iron body, bronze wedges; non-rising bronze stem and O-ring packing.
  - .2.3 Piping: Piping shall be Clow mechanical joint ductile iron (AWWA C106) 250 pounds working pressure with cement-lining, class 52 thickness bitumastic enamel coating, and rubber ring gasket.
  - .2.4 Valve Boxes: Auxiliary valve boxes shall be Clow #F-2450 cast iron three piece screw extension type with labeled lid as required by local code.
  - .2.5 Design: The design shall be such that the stresses generated by a smashing blow will be localized and concentrated at a predetermined point in the couplings, straining the metal at this point beyond its ultimate tensile strength before a similar condition develops in the adjacent sections of the standpipe and stem. This design must assure that the upper and lower sections of the hydrant will break apart cleanly without bending the stem and without damage to the working parts of the hydrant, or the abutting parts of the standpipe sections; also, that there will be no leaking or flooding. The upper section of the standpipe which carries the nozzle shall be secured to the lower section in such a manner that the upper section may be revolved, thus permitting the relocation of the nozzle to any desired direction. The hydrant shall be so designed that, if broken at the joint, repairs may be made by the use of simple tools and the minimum number of parts, and without the necessity of excavating or shutting off the water supply to

## DIVISION 21 – FIRE SUPPRESSION

---

the hydrant. It shall be designed so that the stem and main valve may be removed through the top of the standpipe without excavating.

- .2.6 Installation: Installation and locations of fire hydrants must conform to the current edition of NFPA Publication 24 and specifications of both The Ohio State University and governing Authorities Having Jurisdiction (AHJ). Locate one fire hydrant near the exterior siamese pumper connection.
  - .2.6.1 All new fire hydrants, auxiliary valves and portion of water lines connected to them shall be a minimum of 4'-6" below grade, but not more than 5'-0" below grade, where possible.
  - .2.6.2 New fire hydrants and their auxiliary valves shall be placed four feet away from sidewalks and roads where possible, and the valves two feet minimum from fire hydrants. Where fire hydrants valves are covered with sidewalks or roads paving (unable to be located) they are to remain as is.
  - .2.6.3 Pipe buried in ground shall have firm bearing along entire length of undisturbed earth. Pipe on fill or loose soil shall be supported every six feet on brick or concrete piers and then firmly embedded in sand. Pipe trenches shall be evenly graded.
  - .2.6.4 Securely anchor each mechanical joint, tee, plug, cap, and bend using pipe clamps, tie-rods and concrete thrust blocks conforming to the requirements of the current edition of NFPA Publication 24.
  - .2.6.5 Install fire hydrant so centerline of all hose outlets are a minimum of twelve inches above finish grade. Hydrants are to be secured with ¾" tie-rods. Use concrete thrust blocks at bases.
  - .2.6.6 Valve boxes are to be installed so tops are flush with grade or pavement.
  - .2.6.7 All fire hydrants shall be installed with Class "C" concrete backing poured against undisturbed earth, as approved by the University.
  - .2.6.8 When main water lines' valves have to be closed for hydrant installation due to fire hydrants valve not being located, this closing shall be coordinated with The Ohio State University Division of Emergency Management and Fire Prevention, and FOD's Utility Services.
- .2.7 Testing: FOD's Utility Services and Division of Emergency Management & Fire Prevention shall witness and approve all hydrostatic pressure tests.
  - .2.7.1 Test at 200 PSIG for two hours.
  - .2.7.2 Provide Contractor's Material and Test Certificate according to requirements of NFPA 13.
  - .2.7.3 The trench shall be backfilled between joints after inspection and before testing to prevent movement of pipe.
  - .2.7.4 Hydrostatic tests shall be made before the joints are covered in order that any leaks may be detected.



## **DIVISION 21 – FIRE SUPPRESSION**

---

.2.7.5 Thrust blocks shall be sufficiently hardened before hydrostatic testing is begun.

.2.7.6 Flush lines prior to testing.

.2.8 Painting: University Fire Hydrants and valve box lids are to be RED with the hydrant caps painted GRAY, similar to existing OSU fire hydrants.

.2.8.1 Factory painted fire hydrants which have been damaged shall be cleaned, primed, and repainted to comply with these standards.

.2.8.2 Gray fire hydrant caps and Red valve box lids are to be painted after the fire hydrants and valve boxes are installed.

.2.9 Inspection: Backfilling will not be permitted until hydrant drain holes are plugged and The Ohio State University Division of Emergency Management & Fire Prevention, and FOD Utility Services has inspected the installation and found it acceptable. Note that existing water lines supplying new hydrants shall be modified by the contractor to bring water line up.

### **21 12 00. FIRE-SUPPRESSION STANDPIPES**

.1 DESIGN, INSTALLATION, AND TESTING: Comply with the Ohio Building Code, the Ohio Fire Code: Ohio Administrative Code - Fire Protection Systems, the Authority Having Jurisdiction (AHJ): Department of Commerce Division of State Fire Marshal, and the requirements of NFPA Publication 14, STANDARD FOR INSTALLATION OF STANDPIPE AND HOSE SYSTEMS. Wherever standpipes are installed, siamese pumper connections shall be provided as required.

.1.1 At the start of design, the design Architect/Engineer remains responsible to perform a flow test and pressure test, to be performed by a service agency licensed and certified by the AHJ to perform such tests. Provide a copy of the flow and pressure test to the University's Project Representative and FOD's Utility Services.

.1.2 When the Ohio Administrative Code requirements for Fire Protection Systems requires standpipe hose connections at the roof level the Architect/Engineer shall coordinate the requirements of the roof access and fall protection system with the Fire Protection System.

.1.3 The Architect/Engineer shall coordinate the specified metal finish of the standpipe's exterior drain pipes with the building's finish materials.

.2 STANDPIPES: In buildings where standpipes are installed, all fire department (2-1/2 in.) valves shall be in a stairwell.

### **21 12 20. FIRE STANDPIPE CABINETS AND ACCESSORIES:**

.1 STANDPIPE CABINETS shall be painted steel, flanged, flush mounted type (similar to extinguisher cabinets), large enough to accommodate a fire extinguisher. Each fire extinguisher and fire valve cabinet may have a break-glass type door with full flat glass in the door. A break-glass tool must be provided attached to cabinet.

.2 ORIFICES: Whenever necessary to ensure that hose pressure does not exceed 60 psig, orifices shall be required on hose cabinet valve-discharges. The orifices shall be the

## DIVISION 21 – FIRE SUPPRESSION

---

adjustable type and shall be properly adjusted by the contractor on the job so that hose pressure does not exceed 60 psig. The Columbus Division of Fire, Fire Prevention Bureau should be consulted on the proper pressure reducing devices. The Architect/Engineer (A/E) is to contact the University's Division of Emergency Management & Fire Prevention prior to contacting the Columbus Division of Fire.

- .3 LOCATIONS: Standpipe and valve cabinets shall be located so that the centerline of the hose valve is in accordance with NFPA Publication 14 recommendations. The full fire rating and acoustical rating of the walls shall be maintained.
- .4 HOSE CONNECTION: Where possible, all valves and fittings for fire department connections shall be rotated approximately 22-1/2° down from vertical to facilitate easy hose connection. Within the City of Columbus, threads shall be Columbus fire threads.
- .5 External to the City of Columbus, threads must be compatible with the equipment of the local fire department.
- .6 RENOVATION PROJECTS: Require that the FOD Operations Fire System Shop be advised to take possession, before construction begins, of existing fire extinguishers for safe keeping.

### 21 13 00. FIRE-SUPPRESSION SPRINKLER SYSTEMS

- .1 SPRINKLER SYSTEMS shall be automatic systems designed, installed, and tested according to the Ohio Building Code, the Authority Having Jurisdiction (AHJ): Department of Commerce Division of State Fire Marshal, the requirements of NFPA Publication 13, STANDARD FOR THE INSTALLATION OF SPRINKLER SYSTEMS.
- .2 SPECIAL INSTALLATIONS: Suppression systems for electrical equipment rooms, elevator equipment rooms, computer equipment rooms or similar spaces shall be designed so as not to present a hazard to occupants or equipment.
  - .2.1 Alternate fire protection systems permitted for these rooms are: (Note: A variance may be required for plan approval by the State of Ohio, Division of Industrial Compliance.)
    - .2.1.1 Foam, NFPA 11.
    - .2.1.2 Carbon Dioxide, NFPA 12.
    - .2.1.3 Water Spray, current edition of NFPA 15.
    - .2.1.4 Dry Chemical, NFPA 17.
    - .2.1.5 Clean Agent Fire Extinguishing Systems, NFPA 2001.
    - .2.1.6 Installation of new NFPA 12A – HALON 1301 FIRE EXTINGUISHING SYSTEMS are prohibited.

COMMENTARY: Existing University HALON 1301 FIRE EXTINGUISHING SYSTEMS are recommended to be removed in lieu of upgrading the equipment, because other substitutes are available for the same uses that pose lower risk overall to human health and the environment. As described in the signed September 16, 1987 Montreal Protocol on Substances That Deplete the Ozone Layer.

- .3 ALTERNATE CONSTRUCTION: If occupancy permits, a firewall separation may be provided. If this construction is used, sprinklers are not required, but a smoke detector connected to the building fire alarm system must be provided.

## DIVISION 21 – FIRE SUPPRESSION

---

- .4 DRY SPRINKLER SYSTEMS: Provide a low pressure switch on all systems to detect a gradual loss of air pressure. Connect switch to fire alarm system as a distinct zone.
- .4.1 Air Compressor shall be on a dedicated electrical circuit.
- .4.2 The electrical switch shall be secured by a common keyed padlock.
- .5 INSPECTOR TEST VALVES: Test valves shall be as remote as possible for each zone, have piped-in drainage to allow for testing without the use of hoses or special adapters, be located in stairwells or some common, easily accessible location and contain a sight glass for visual inspection of the flow. Each sprinkler zone shall include one drain and one test station. The locations shall be coordinated with the Architect/Engineer and the University's Division of Emergency Management and Fire Prevention.
- .6 All actual devices for low suction pressure, fire pump interruption, tamper switches, and pump room flow switches shall be wired into the main fire alarm panel, by the Electrical Contractor, as distinct zone annunciation. Specify and show which devices are to be furnished and installed by the Fire Protection Contractor.
- .6.1 *Cord type tamper switches are prohibited.*
- .7 All pressure switches, pumps, valves and similar devices shall be installed with isolating valves to facilitate replacement of devices.
- .8 All pumps, valves and similar devices shall be painted red. All piping shall be painted red or permanently banded red.
- .9 System shall include back flow protection on the domestic water line as required to be consistent with the requirements of the local water department.
- .10 The fire suppression system piping requirement shall meet or exceed the NFPA 13 Standard for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use and be not less than schedule 40.
- .11 Fittings Materials and Dimensions: Cast Iron Threaded Fittings, Class 250 ASME B16.4; Malleable Iron Treaded Fittings, Class 300 ASME B16.3; Malleable Iron Threaded Pipe Unions, Class 250 ASME B16.39
- .12 Braided stainless steel flexible fire sprinkler drop hose that are U.L. Listed/FM Approved are allowed.

### 21 30 00. FIRE PUMPS

- .1 CENTRIFUGAL TYPE PUMPS shall be provided; turbine vane pumps are prohibited. Installation shall comply with the Ohio Building Code (OBC), and NFPA Publication 20, STANDARD FOR THE INSTALLATION OF STATIONARY PUMPS for FIRE PROTECTION.
- .2 CONTROLLER: Specify the following, all factory prewired and enclosed in a NEMA II floor mounted enclosure: One excess pressure controller containing magnetic starter, disconnect switch, dual pressure switch, three position selector switch, and an alarm bell to sound when the pressure drops below the second control point of the dual pressure switch.

## **DIVISION 21 – FIRE SUPPRESSION**

---

- .2.1 Coordination of Electrical Connections: Stipulate that the pump supplier coordinate the electrical connection lugs with the cable size being provided by the electrical contractor or provide junction boxes and terminal strips to match wire sizes indicated in the motor schedule on the electrical drawings.
- .3 BEARINGS: Wherever practical, equipment shall be furnished with sealed ball or roller bearings. Specify that the contractor shall not lubricate sealed bearings.
- .4 RELIEF VALVE AND DRAIN: The fire pump shall have a temperature relief valve integral with the casing. A valved discharge line to a test header located outside the building shall be provided for demonstration and operating tests. Provide an automatic ball check and drain line, piped to drain from the discharge line and test header system
- .5 FIRE PUMP TEST CONNECTIONS: The test connection cluster, with 2-1/2 in. valves; shall be located on the building exterior adjacent to the fire department siamese connection for the purpose of performing proper testing of the fire pump for initial acceptance and annual testing. Include piped drainage. Test valves shall have piped in drainage. The Architect/Engineer shall coordinate the site requirements for the test vehicle/trailer and water discharge to prevent damage to the landscape and building.
  - .5.1 All Fire Department Siamese Connections (FDC) shall require locking caps that accept KNOX key wrench.

### **21 31 00 SIGNAGE**

- .1 The Architect/Engineer (A/E) shall specify the SIGNAGE REQUIREMENTS PER OHIO FIRE CODE. A/E shall also review APPENDIX S of the Building Design Standards and list the signage requirements in Division 10 Signage as part of the General Contract.
- .2 FIRE DEPARTMENT CONNECTION
  - .2.1 The location of the fire department connection shall be indicated by the permanent installation of a readily visible sign. Such sign shall have the letters “FDC” at least 6 inches (152 mm) high and words in letters at least 2 inches (51mm) high or an arrow to indicate the location. The color of the letters is to contrast with the background color, e.g., white letters on red background. The Architect/Engineer shall coordinate the location of the sign with the University Project Representative and the Division of Emergency Management and Fire Prevention and the AHJ.
- .3 STANDPIPE CONNECTION CABINETS
  - .3.1 The location of the fire department standpipe connection cabinets shall be identified with a permanently installed sign with letters at least 1 **inch** high in a color that contrasts with the background color, to read “Standpipes”.
- .4 FIRE EXTINGUISHERS
  - .4.1 The location of installed fire extinguishers within a cabinet shall be properly identified by the labeling above the cabinet with dimensional signage using proper wording and/or pictorials.
- .5 FIRE PUMP ROOM

## **DIVISION 21 – FIRE SUPPRESSION**

---

- .5.1 Fire protection equipment shall be identified in an approved manner. Rooms containing controls for fire suppression pumps shall be identified for the use of the fire department. Signage shall be constructed of durable materials permanently installed and readily visible to read, "FIRE PUMP".

### **.6 SPRINKLER RISERS AND VALVES ROOM**

- .6.1 Fire protection equipment shall be identified in an approved manner. Rooms containing controls for all fire suppression sprinkler risers and valves, including dry and pre-action suppression systems shall be identified for the use of the fire department. Signage shall be constructed of durable materials permanently installed and readily visible to read, "SPRINKLER ROOM".

---

END OF DIVISION 21 – FIRE SUPPRESSION

## DIVISION 22 – PLUMBING

2006 Edition, Published January 1, 2006; Division Revision Date: February 7, 2017

### 22 00 00. PLUMBING

#### 22 00 03. GENERAL PROVISIONS

- .1 ALTERNATES OR ALTERNATIVES: Refer to Division 01 for instructions regarding use of the word "Alternate".
- .2 ALTERNATE MATERIALS FOR ACID WASTE SYSTEMS: Refer to 22 10 00 for pipe and pipe fittings. One of the acceptable materials shall be specified as the base bid and one or more of the others shall be specified as an alternate. Acid dilution tanks, which are a part of acid waste systems, should be located in such a way that they are easily accessible for servicing.
- .3 CODES: All materials and installations shall be compliant with the current Ohio Building Code, and the current Ohio Plumbing Code.
- .4 SEWER AND WATER TAPS: City of Columbus Sanitary Sewer Tap Fees and System Capacity Charges shall be paid by the contractor doing the work. Costs of and arrangements for sewer and water taps, including capacity charges, must be resolved with the University Architect before preparation of final documents. Also see Division 33 – Utilities Site Utilities.

#### 22 00 05. SUBMITTALS:

- .1 STATE INSPECTION CERTIFICATE: Soil, waste, and vent piping shall be approved by the State of Ohio Department of Health. Work shall be inspected by the State Plumbing Inspector and a copy of the final inspection certificate shall be delivered to the University Architect.
  - .1.1 Fees: Specify that inspection fees shall be a part of the contractor's job cost.
- .2 TEST REPORTS: Submit reports of all tests required by 22 00 07.

#### 22 00 07. TESTING

- .1 Underground Water Service Piping: See Division 33 Section 33 11 13 Site Water Distribution.
- .2 Interior Water Piping: Test with water, at 125 psig pressure, for a period of not less than 6 consecutive hours.

**Student Life:** prior to water testing interior water piping, test with air where it is permissible with Ohio Plumbing Code.

- .3 Domestic Water Supply Piping: Flush and sterilize under the supervision of a qualified consultant. Provide the University Architect with written certification of sterility and confirm that the piping system is clean and safe to transmit water for human consumption. The sterilization method to be followed shall be that prescribed by the health authority having jurisdiction or water purveyor having jurisdiction, or in the absence of a prescribed method, the procedure described in either AWWA C651 or AWWA C652 or their successors, or as described in the Ohio Building Code, Ohio Plumbing Code Section 610.1, whichever is the more stringent.
- .4 Interior Gas Piping: Test with nitrogen for a period of 24 consecutive hours in conformance with the rules and regulations of the local gas supplier. Submit test report to University Project Manager through A/E.

## DIVISION 22 – PLUMBING

---

- .4.1 A minimum of 48-hour notice shall be given in writing to the University Architect prior to the purging of lines. Purging shall be performed in conformance with recommendations of and under supervision of the local gas supplier. Venting during purging operations shall be to the outside of buildings at a safe location.
- .5 Exterior Storm and Sanitary Sewers: Test according to the requirements of the City of Columbus Section 901.10 of the Construction and Material Specifications, or to the Ohio Building Code, Ohio Plumbing Code, or to the Authority Having Jurisdiction, whichever is the most stringent.
- .6 Compressed Air Piping (regular pressure): Test to 125 psig for 6 hours.
- .7 LP Gas Systems: Should be purged and tested in accordance with the latest edition of NFPA 58. Submit test report.
- .8 Oxygen and/or Surgical or Miscellaneous Gas Lines: Test as recommended by National Cylinder Gas and NFPA. Consult the University Architect for any special testing or purging requirements.
- .9 Recording Line Charts shall be specified for all gaseous pressure testing.
- 10 Compressed air and laboratory gases above 150 psig shall be inspected, examined, and tested per the requirements of Chapter VI of ASME B31.3. A third-party inspector shall be hired by the A/E (Criteria A/E for design-build) and subject to approval by the University.
- 22 00 09. RELATED WORK IN GENERAL CONSTRUCTION:
  - .1 WATER SUPPLY PIPING INSTALLATION:
    - .1.1 Provide a minimum of 48 inches cover over pipe to prevent freezing.
    - .1.2 Provide concrete anchors and steel yokes on all fittings with over 1/16 bend. Details shall be shown on drawings.
    - .1.3 A 2 feet wide by 1 foot thick reinforced concrete bridge beam shall be keyed into the foundation wall immediately under any water service line to the building. This beam will be carried out from the building wall to firm support beyond the excavation for the building wall.
  - .2 GAS PIPING BACKFILL: Specify that no backfill operations be performed until piping installation has been tested and approved.
    - .2.1 Sand: Use only clean sand, free of rubble and rocks of 1- 1/2 inch diameter or greater.
    - .2.2 Backfilling: Deposit sand to a depth of 3 inches above and below piping. Caution the contractor to exercise care to prevent breaking of wires and displacement of anodes. Remainder of backfill shall be made with clean excavated material free of rubble, rocks, bricks, wood or debris placed and compacted in accordance with requirements stated in Division 2 of these guides. Grits are prohibited.
  - .3 CLEANING AND PAINTING: Cleaning of fixtures and equipment shall be included in the Plumbing Contract. Painting may be a divided responsibility of the General Contractor and the Plumbing Contractor. The A/E shall coordinate the specifications to clearly indicate each contractor's responsibilities in order to avoid double costs for identical work or total omission of the work. See Section 09 90 00. Color for the exterior exposed gas pipes should be consulted and approved by University landscape Architect and University Utilities.

**22 05 05. PLUMBING MATERIALS AND METHODS**

22 05 07. SLEEVES: Sleeves shall be provided for piping through all walls and floors. See Facility Services-3.12 through 3.12.3.4.

22 05 09. SUPPORTING DEVICES: Refer to PART FOUR, Facility Services-3.15 and 3.19.2 for general requirements.

22 05 20. GAUGES AND THERMOMETERS

.1 METERS: Permanent utility services to each building require permanent metering.

**Student Life:** requires metering and submetering for each individual building. Meters must also be accessible remotely.

.2 GAUGES:

.2.1 Gauges shall be 4-1/2 inches in diameter single spring type with recalibration adjustment in the dial face and with gate valve shut-off. Tailor the range to the application. Gauges shall not be positioned over 6 feet above the floor; install remote sensing gauges as required to conform with this restriction.

.2.2 Water supply: Locate a pressure gauge at the water service entrance and elsewhere as needed to properly identify pressure within the piping system.

.2.3 Domestic hot water: Locate pressure gauges on suction and discharge sides of pumps and elsewhere as needed to properly identify pressure within the piping system. When hot water is supplied by the power plant, provide gauges on both supply and return.

.2.4 Gas service: Locate pressure gauges at the service entrance and upstream and downstream of pressure regulators.

.2.5 Other piped systems: Locate vacuum or pressure gauges as required to properly identify pressure within each system. Provide pressure gauges at entrance and exit locations for steam supply, condensate return, hot water supply and hot water return.

.3 THERMOMETERS:

.3.1 Thermometers shall be digital or mercury-free, red or blue-reading-in-glass type with 9-inch magnified column, Fahrenheit scale, recalibration feature, and adjustable head. Tailor the range to the application. Installation shall be in brass or stainless steel pressure tight separable well with heat transfer paste. Thermometers shall not be positioned over 6-feet above the floor; install remote head type of thermometers as required to conform with this restriction. Provide a building automation sensor well adjacent to thermometers at major plumbing system equipment (e.g. domestic hot water heaters, central distribution mixing valves, etc.)

.3.2 Piped systems and storage tanks: Locate thermometers as required on all systems or tanks where temperature should be identifiable for operation and maintenance. Provide at building entrance and exit locations for domestic hot water supply and return.

22 05 25. VALVES

.1 GENERAL REQUIREMENTS



## DIVISION 22 – PLUMBING

---

- .1.1 Each valve-type (e.g. flush valves, ball valves, balance valves, etc.) provided for a single project shall be products of a single manufacturer. Specify three (3) equivalent manufacturers, approved by University Engineer, for the contractor to select from.
- .1.2 Valve tags: Specify that each valve in each piping system be tagged with a brass or aluminum tag numbered consecutively for each system and attached to the valve with a brass or aluminum chain. Valve tags shall have stamped abbreviations of the system in addition to the valve number.
- .1.3 Valve chart: The A/E shall determine the location for installation of a valve chart and shall specify that a typewritten directory of all valve numbers (by system, describing location) be furnished, framed under glass, and installed in the equipment room where indicated. A copy of the valve directory shall be bound in a hard fiber binder, along with an electronic copy, and delivered to the A/E for forwarding to the University's Project Manager.

**Student Life:** The A/E shall provide an additional electronic copy of the valve chart to Student Life's Office of Facility Management & Logistics for the project.

- .1.4 Design requirements:
  - .1.4.1 Shut-off valves shall be provided on all branches off main water lines and ahead of dielectric unions. Branches shall be provided with drain valves to facilitate drainage of branches.
  - .1.4.2 Fixture Stops: Each fixture and piece of equipment shall be provided with a fixture stop. Groups of fixtures shall be valved separately. Stops for flush valves shall be screwdriver stops with protective caps; all other shall be quarter turn ball valves. Handwheel stops are prohibited.
  - .1.4.3 Unions and Fittings: A union or bolted flange fitting shall be provided downstream of, and within approximately 12 in. of each valve, and adjacent to both inlet and outlet of pumps and other equipment.

**Student Life:** This rule only applies to valves three inches or larger.

- .1.4.4 Flush Valves: Expose for easier maintenance.

### .2 GATE VALVES:

- .2.1 2-1/2 inches and smaller, brass or bronze body, trim and stem, solid wedge, rising stem, union bonnet, 125 pounds screwed ends.
- .2.2 3 inches and larger, iron body, bronze trimmed, O.S. & Y. 125 pounds flanged, (conforming to the City of Columbus Item 802).
- .2.3 All gate valves shall be full port.

### .3 VALVE BOXES: Valve boxes shall be furnished on all valves of water service piping. Boxes shall be extended to final grade or pavement. The word "WATER" shall be cast in the cover. A 3 inches galvanized steel pipe shall be installed in each valve box to prevent misalignment. Liners shall be removed as the last item of work at the installation.

### .4 GAS COCKS:

- .4.1 1-1/2 inches and smaller, screwed, all brass 150 lb. WOG.
- .4.2 2 inches and larger, lubricated types, 175 pounds WOG.

## DIVISION 22 – PLUMBING

---

.4.3 Valves shall be labeled as required to be compliant with all requirements of the International Fuel Gas Code (IFGC), as referenced within the Ohio Building Code.

### .5 GLOBE AND ANGLE VALVES:

.5.1 2-1/2 inches and smaller, brass or bronze body, trim and stem, union bonnet, 125 pounds screwed ends.

.5.2 3 inches and larger, iron body, bronze trimmed, 125 pounds flanged.

.5.3 All globe and angle valves shall be full port.

### .6 CHECK VALVES:

.6.1 2-1/2 inches and smaller, swing check type, brass or bronze, renewable, disc, 125 pounds screwed ends.

.6.2 3 inches and larger, swing check type, iron body, bronze trimmed, bolted cap, 125 pounds flanged ends.

.6.3 Spring loaded check valves, flanged silent center guide, 250 lb. semi-steel body, bronze stem, 1/16 inch raised face.

**Student Life:** Only allows the spring loaded type check valves. Deviations from this requirement shall go through BDS variance process.

### .7 BALL VALVES:

.7.1 3 inch or smaller, two or three piece bronze body, full port, screwed ends, chrome plated brass or stainless steel ball, steel stem, reinforced TFE packing and seat ring with appropriate pressure and temperature rating for specific application.

### .8 BUTTERFLY VALVES:

.8.1 2 inch or larger, ductile iron disc and body, geometric drive, molded in seat liner, stainless steel stem, EPDM rubber liner, 125 pounds. Lug or wafer style.

.9 BACKFLOW PREVENTION DEVICES: As required and specified per Ohio Building Code, Ohio Plumbing Code and all referenced ASSE standards. Provide 3/4-inch minimum size drain line to floor drain. Units must be removable and accessible for maintenance. The Ohio Environmental Protection Agency specifies those situations in which backflow prevention devices and arrangements shall be used. Code-approved air gaps are recommended and pumping units with code-approved air gaps are also recommended. Where air gaps and vacuum breakers are not acceptable, products of the following manufacturers of backflow prevention devices are approved:

Size in Inches	Model	Manufacturer
1/2" through 10"	BEECO	MIFAB, Inc Chicago, IL 60643
3/4	#80-0059	The Toro Co. San Marcos, CA 92069
1	#9- 2770	The Toro Co.
3/4; 1; 1-1/4, 1-1/2; 2; 3	#900	Watts Regulator Co. Lawrence, Mass. 01842

## DIVISION 22 – PLUMBING

---

- |  |     |        |  |
|--|-----|--------|--|
|  | 3/4 | BF-075 | Richwell Valve Co.<br>Santa Anna, CA 92707 |
|  | 1   | BF-100 | Richwell Valve Co.                         |
- 22 05 50. VIBRATION AND SEISMIC CONTROLS
- .1 DESIGN REQUIREMENTS: Refer to PART ONE. Specify sound emission and transmission controls as required to meet standards indicated in the Table entitled, "Ranges of Design Limits for Sound Control" in the Appendix, or when applicable, to meet Federal standards.
- .2 WATER SUPPLY PIPING: Shock absorbers shall be provided in accordance with the Plumbing and Drainage Institute Standard PDI-WH201. Shock absorbers shall have stainless steel air chamber and brass, bronze, or stainless steel body.
- .3 COMPRESSED AIR SYSTEMS: Vibration isolators or inertia pads shall be provided under air compressors. Flexible connectors shall be provided on discharge line of compressor.
- .4 DOMESTIC HOT WATER SYSTEMS: Branch connections to hot water risers shall be designed with adequate provision for movement.
- .5 VACUUM PUMPS: Shock absorbers shall be provided similar to those for Water Supply Piping.

### 22 07 00. PLUMBING INSULATION

#### 22 07 16. PLUMBING EQUIPMENT INSULATION

- .1 STORAGE TANK INSULATION: Insulation for hot water and cold water storage tanks shall comply with Federal Specifications HH-I-530A or its successor.
- .1.1 For domestic hot water storage tanks: Recommended thickness 2 inch, density 6 pounds/cubic foot, compressive strength 300 psi at 10% deformation, thermal conductivity .32 Btu/(hour) (square foot) (F degrees/inch) at 175 degrees mean temperature.
- .1.2 For cold water tanks: Recommended thickness 2 inch, density 9 pound/cubic foot, compressive strength 530 psi at 10 percent deformation.
- .2 FLUE INSULATION: Domestic hot water heater flues shall be insulated when required for safety or for reducing heat transfer.

**Student Life:** Closed cell elastomeric flue insulation shall be used on all non-steam applications. The materials shall be rated for proper application temperature and code compliant fire/smoke rating.

#### 22 07 19. PLUMBING PIPING INSULATION

- .1 PIPING INSULATION: Fibrous glass, or equal mineral fiber, molded sectional type covering. Asbestos is expressly prohibited and water-soluble treatment of insulation jacket to impede or retard flame or smoke is also prohibited. Insulation thickness and R-value shall be as required by the Ohio Building Code, Ohio Plumbing Code, whichever is more energy efficient

**Student Life:** Closed cell elastomeric pipe insulation shall be used on all non steam applications. The materials shall be rated for proper application temperature and code compliant fire/smoke rating.

## **DIVISION 22 – PLUMBING**

---

- .1.1 Concealed locations: Insulation for cold water piping shall be provided with a factory-applied fire retardant vapor barrier jacket with self-sealing lap; insulation for domestic hot water piping shall be provided without vapor barrier.
- .1.2 Exposed locations: Insulation for both cold and hot water piping in exposed locations shall be of 7 pound density and jacket shall have pre-sized glass cloth.
- .1.3 Insulation for interior downspout piping, roof drain sumps, water cooler wastes, and chilled water wastes shall be of 7 pound density, with or without jacket as required for the location.
- .1.4 Thicknesses:
  - .1.4.1 Insulation on cold water piping, interior downspout piping, roof drain sumps, water cooler wastes, and chilled water wastes shall be at least 1/2 inch thick. Insulation on piping 3 inch and larger shall be at least 3/4 inch thick.
  - .1.4.2 Insulation on domestic hot water lines 2 inch and smaller shall be 1 inch thick. Insulation on piping 2-1/2 inch and larger shall be 1-1/2 inch thick.
- .1.5 Installations: Insulation shall be installed over hangers and supports and shall be carried continuous through all sleeves. In addition to the following requirements, specify any other insulation required. All of the following piping shall be insulated:
  - .1.5.1 Cold Water Lines.
  - .1.5.2 Domestic hot water lines, including recirculating lines and storage lines.
  - .1.5.3 Horizontal runs from roof drains and horizontal downspouts, inside buildings.
  - .1.5.4 Roof drain sumps, inside buildings.
  - .1.5.5 Exposed horizontal waste lines from water coolers and lines carrying chilled water waste.

### **22 10 00. PLUMBING PIPING AND PUMPS**

#### **22 10 05. PIPE AND PIPE FITTINGS**

##### **.1 PROHIBITED INSTALLATIONS:**

- .1.1 Water, sewer, drain, steam, condensate and gas lines shall not be designed for installation over electrical switchgear and transformers, or in elevator or electrical equipment rooms and shafts. This is not intended to prohibit sprinklers in electrical equipment rooms.
- .1.2 Bullhead connections in any piping service are expressly prohibited except air, gas or cold water lines.
- .1.3 Glass waste piping under slabs or underground is prohibited.

- .2 **STEEL PIPE:** A120/A53 is acceptable in lieu of either A120 or A53 Type F, provided that all of the other restrictions governing the use of either grade are followed. If the dual graded pipe is to be used in place of A53, Type F, the vendor will provide mill certification signed by the manufacturer's chief metallurgist. Said certification shall conform to the ASTM A-53 requirements for chemistry, tensile, bending/flattening, and hydrostatic testing. It is strongly

## DIVISION 22 – PLUMBING

---

recommended that, if dual graded pipe is specified, that it be specified as domestically produced so that the University has recourse in event of non-specification compliance.

### .3 UNDERGROUND WATER PIPE

.3.1 Underground Water Pipe (Exterior) See Division 33 Section 33 11 13 Site Water Distribution.

.3.2 New domestic cold water utility piping shall not be designed to be routed through campus tunnels or through campus facilities. If no other reasonable alternative exists, routing the underground domestic cold water utility through a tunnel or through a campus facility requires a design variance submitted to the University Engineer. Any exposed domestic cold water pipe must be designed with restraints to account for thrust forces. The project designing and installing the exposed domestic cold water line shall provide third party inspection on the installed water line prior to the water line being energized for testing.

### .4 INTERIOR COLD WATER AND DOMESTIC HOT WATER PIPING: Branch off with valves to isolate areas of the building so that the entire water supply does not have to be shut off during repairs.

.4.1 4 inch and smaller, hard drawn type L copper tubing, with cast bronze or wrought copper class 150 lb., socket solder fittings or press fittings made out of bronze or copper conforming to ASME B16.18 or ASME B16.22 and performance requirements of IAPMO PS 117. Press fittings shall have factory-installed EPDM sealing element and leak detection feature.

.4.2 6 inch and larger, galvanized steel pipe, Schedule 40, conforming to ASTM-A53, Type E, Grade B. Fittings shall be Class 150 lb. malleable iron, galvanized, screwed pattern. Fittings, on 10 in. and larger, cast iron with Class 125 lb. flanges.

### .5 DRIP LINES: Type L copper tubing with copper fittings.

### .6 SPECIAL PIPING

.6.1 Distilled water: Schedule 80 CPVC, "Orion White Line" or Enfield "Purity Sustained" polypropylene plastic or tin-lined copper pipe with appropriate fittings may be used. If plastic is used, quality control of joint fusing is critical to performance.

.6.2 Compressed air piping: Seamless hard-copper tubing, type L or K, with cast bronze or wrought copper class 150 lb. socket solder fittings.

.6.3 Oxygen pipe lines: Cleaned seamless copper tubing, type K or L, or Schedule 40 brass pipe. Fittings shall be cleaned wrought copper.

.6.4 Other: Pipe and fittings for acid distribution, alkaline distribution, process piping, lubricating oil, high pressure, unusual gases, etc. shall be individually reviewed with the University Engineer. Also see 22 20 07.

.6.4.1 Compressed air and laboratory gases above 150 psig shall be designed, fabricated, and installed to comply with ASME B31.3. Such piping shall be inspected, examined, and tested per the requirements of Chapter VI of ASME B31.3. A third-party inspector shall be hired by the A/E (Criteria A/E for design-build) and subject to approval by the University.

## DIVISION 22 – PLUMBING

---

- .6.5 Medical Gas piping: Medical gas designs, materials, and installations shall be compliant per Ohio Building Code, Ohio Plumbing Code, and NFPA 99C, ASME B31.1, NFPA 50, and NFPA 51.
  - 6.6 Reverse osmosis permeate (product water) piping: Specify schedule 80 PVC, 316 stainless steel, or high purity polyvinylidene fluoride (PVDF) (complete system by SYGEF or Simtech) piping and fittings as appropriate for application. Do not specify copper.
  - 6.7 Process cooling piping: Material selection shall be suitable for the application and compatible with laboratory equipment being served.
- .7 GAS PIPING:
- .7.1 Underground Natural Gas Lines (piping): See OSU BDS Division Underground Natural Gas Line 33 51 13.
  - .7.2 Interior piping shall be Schedule 40, A120/A53, ASTM A-120, Type F, or ASTM A53, Type F, Grade B black steel pipe. Joints in 1-1/2 inch and smaller pipe may be screwed. Fittings, class 150 lb. banded, malleable iron, black. Use of bushings is prohibited. Weld joints in pipe 2 inch and larger. Use backing rings for welding 8 inch and larger pipe.
  - .7.3 Specify that all steel pipe risers shall be cathodically protected from corrosion and electrically isolated from building grounds.
- .8 PIPING FOR SOIL, WASTE, AND STORM DRAINS
- .8.1 Exterior storm sewers: (Minimal pipe size shall be 8" for all piping that is not a roof leader) Acceptable materials are type PSM PVC pipe for 4 inch and 6 inch diameters conforming to ASTM D-3034, extra strength ASTM C700 vitrified clay pipe for 4 inch and larger diameters, and reinforced concrete pipe (ASTM C-76 deleting Sections 3.1.2 and 11. regarding design, concrete compression testing and production core and cylinder tests) for 6 inch and larger diameters, and corrugated polyethylene N-12 pipe conforming to ASTM-F405 and AASHSTO M252 for pipe 4" to 36" in diameter.
    - .8.1.1 For clay pipe, joints shall conform to ASTM C-425 Compression Joints for Vitrified Clay Bell and Spigot Pipe. For concrete pipe, joints shall conform to ASTM C-443 Type A Rubber Gasket. Also see 22 20 07.
  - .8.2 Exterior sanitary sewers: Acceptable materials are type PSM PVC pipe for 4 inch diameters conforming to ASTM D-3034, extra strength vitrified clay pipe for 4 inch and larger diameters and service weight cast iron pipe for 4 inch and larger diameters, and PVC SDR-26 pipe for 6" and larger diameters.
  - .8.3 Interior acid waste and vents: Piping above grade may be either Borosilicate glass or Duriron or polypropylene. Duriron shall be used below grade. See 22 00 03 and 22 20 07 .
  - .8.4 Interior vents, soil, waste and storm drains except underground: Extra-heavy or service weight centrifugally cast iron soil pipe with lead, rubber gasket or "no hub" joints may be used for 1-1/2 inch diameter and larger pipe. When rubber gaskets are used, specify "Dual-Tight" or "Ty-Seal" with lubricant equal to "Lubrifast". Schedule 40 ASTM A120, type F, galvanized steel pipe, with galvanized cast iron drainage type fittings may be used for 2-1/2 inch diameter and smaller. Type L copper tubing and copper drainage fittings for waste and type M copper tubing for vents may be used for 4 inch diameter and smaller. Provide structural support for large pipe and lateral

restraint for all kinetic forces. PVC piping for interior vents, soil, waste and storm drains including using as sleeves shall be required prior approval from University Engineer.

**Commentary:** Approval from University Engineer on interior PVC piping is typically contingent upon whether the following issues have been addressed or not:

- Project manager has verified with User that noise won't be an issue to the User should PVC piping be used.
- PVC will not be used in plenum areas.
- A/E has confirmed that the waste to be discharged is compatible with the PVC material.
- A/E has specified the appropriate cement for the PVC pipe joining.
- A/E has included details for PVC piping penetrating floors and/or fire rated walls.

.8.5 Interior underground vent, soil, waste and storm drains: Extra-heavy weight centrifugally cast iron soil pipe with lead, rubber gasket or "no hub" joints may be used. When rubber gaskets are used, specify "Dual-Tight" or "Ty-Seal" with lubricant equal to "Lubrifest". Type K copper tubing and copper drainage fittings may be used for 3 inch diameter and smaller.

.9 COPPER CONNECTIONS: Solder joints for copper water lines shall be made with no-lead solder in order to minimize the exposure to lead; water coolers must be lead-free.

.9.1 Copper joints: Copper piping less than 2 inch may be soldered using 95/5 tin/antimony solder. Copper piping 2 inch and larger shall be brazed, using a 6 percent silver alloy with a 1000°F solidus minimum and comparable to J.W. Harris Co., Dynaflo.

.9.2 Connections between copper and steel piping: Those carrying water shall be made with an approved type dielectric nipple or flange. Specify that all dielectric nipples used have at least 250°F temperature rating.

## **22 14 00. FACILITY STORM DRAINAGE**

1 ROOF DRAINAGE:

.1.1 COORDINATION: Location and depth of drains shall be carefully coordinated to assure adequate pitch of the drainage area to drain.

.1.2 DRAINS: Roof drains shall be cast iron with removable combined beehive strainer and sediment cup. Roof drains for multistory building or one-story buildings equivalent to at least two stories in height shall be provided with integral expansion joint.

.1.3 FLASHING: Drains shall be installed with lead sheet weighing not less than 6 pounds per square foot extending a minimum of 12 inches in all directions outward from the clamping ring. Lead flashing shall be placed below the roof insulation, and insulation shall be tapered down to the drain. Specifications shall call attention to the requirement for coordination with the installation of roofing.

.1.4 CONNECTIONS: Preferred approach is to drain roof drainage to storm water best management practices (BMPs) rather than direct connection to piped storm water conveyance systems.

.2AREA DRAINAGE:

## DIVISION 22 – PLUMBING

---

- .2.1 OPEN AREA DRAINS: Where drains are subject to clogging with leaves, select drains which will avoid pooling of water.
- .2.2 AREAWAY DRAINS: In areaways, at landings at the foot of exterior stairways, and similar locations, provide angular strainers at the wall and floor intersection, so vertical face acts as an overflow when the horizontal portion of the grating is obstructed.
- .2.3 WHEELCHAIR RAMPS: Where drainage is required at the base of wheelchair ramps, trench drains shall be used with slotted grating designed not to create a hazard to wheelchairs.

### 22 20 00. PLUMBING SYSTEMS

#### 22 20 05. WATER SUPPLY SYSTEM

- .1 Refer to PART ONE and to paragraph 22 00 09 for particular items requiring coordination with General Construction.
- .2 STERILIZATION: Specify that new and reworked domestic water piping be sterilized by a firm regularly engaged in the performance of pipe sterilization.
- .3 DESIGN OF SYSTEM:
  - .3.1 Provisions for Expansion and Movement in piping shall be shown on the drawings.
  - .3.2 Unions shall be provided at the following locations:
    - .3.2.1 Adjacent to and downstream from all valves.
    - .3.2.2 At final connections to all items of equipment.
    - .3.2.3 At connections to all plumbing fixtures.
    - .3.2.4 Unions or flanged connections - where required for construction or assembling purposes.
  - .3.3 Water service lines shall not be caulked and leaded into a building wall; tar, rubber, or some other soft material shall be used. Special wall sleeve fittings with soft rubber seals are approved. A swing joint shall be provided on water lines just inside the building, to compensate for pipe movement. Specify that threading of cast iron or ductile iron pipe is prohibited.
  - .3.4 In buildings containing laboratories, water lines to drinking fountains shall be run on separate risers connected to the mains ahead of laboratory equipment lines. Vacuum breakers shall be provided at all laboratory equipment and laboratory water lines.
  - .3.5 Check valves shall be provided on showers, automatic washers, housekeeping closet decks and other items or equipment equipped with cold and hot water mixers. All check valves shall be easily accessible.

**Student Life:** check valves are not required on shower valves, however, shower valves must meet the following criteria: single handle pressure-mixing valve, with single bronze stem, housing stainless steel balancing piston sealed in stem assembly. Must hold shower temperature steady with pressure fluctuations up to 85%. Double seal packing with adjustable brass nut. Brass adjustable limit stop screw to prohibit valve handle to



be turned to excessive hot discharge temperatures. All trim to be copper nickel chrome plated. Service stops to be brass and cast integral with valve body. Combination divertor and volume control to be cast integral with the valve.

22 20 06. DOMESTIC HOT WATER

.1 DESIGN OF SYSTEMS

- .1.1 Domestic hot water systems shall be designed to reasonably assure an expeditious flow of hot water at ALL outlets. When the facility is large (i.e., multistory laboratory building) or the system is large to support heavy flow (i.e., hospital or gymnasium showers) with central domestic water heating, the design shall include recirculating line(s) and pump(s). When the total facility requirements are minimal and compact (i.e., fixture count of a small residence), or in the case of an isolated and remote minimal requirement in a large facility, the economics of space requirements and recirculating system must be calculated. An independent residential size water heater, backed up to the fixture(s) location, without recirculating system may be most appropriate. As a rough guide, domestic hot water systems shall dispense hot water after a flow of not over 1-1/2 quarts or within 10 seconds.
- .1.2 A Recirculating Line shall be provided for all mains. Except for short runouts, lines shall be a minimum of 3/4 inch for large facilities. See paragraph 22 20 06.1.1.
- .1.3 Unions or Flanged Connections shall be provided as specified in paragraph 22 20 05.3.2 .
- .1.4 Maximum Fouling Factor shall be used in sizing domestic hot water heaters. Factory assembled units are recommended; installation should be by the manufacturer or his approved representative.
- .1.5 Domestic Hot Water Heaters: Integral heat exchangers with storage tank assemblies are prohibited. Separate heat exchangers and storage tanks or instantaneous heat exchangers are acceptable, dependent on the application. Water-to-water heat exchangers shall be double-wall construction.
- .1.6 Shielding shall be specified around the packing areas of all circulating pumps.

22 20 07. SOIL AND WASTE SYSTEMS

.1 GENERAL PROVISIONS:

- .1.1 Preparation of Contract Documents: Refer to PART ONE. Consult the University Architect regarding labor jurisdictional decisions in the area where the project is located. Sewerage from 5 feet outside building walls might become a part of the General Contract. See 22 10 05.8.1 .
- .1.2 Applicable Specifications and Codes: Sanitary sewers external to a building shall conform to the requirements of local jurisdiction.
- .1.3 Refer to paragraph 22 00 05 , 01 33 13 and 01 77 00 for submittals, test reports and certificates required.

.2 DESIGN OF SYSTEMS:

## DIVISION 22 – PLUMBING

---

- .2.1 Combined and Separate Systems: Combined storm and sanitary drains within the building structures are prohibited; each shall be run out of the building separately. (Part of the Columbus campus is served by a combined sewer system and part by separate sewer systems. The A/E shall obtain information from the University Architect relative to the sewer arrangement for each building area.) On regional campuses, storm and sanitary systems shall be designed as separate systems.
- .2.2 Storm Sewer Catch Basins and Roof Drains shall not be connected to sanitary systems except with specific permission from the University Architect. If such permission is granted, catch basins shall be parged inside and provided with inverted elbow traps with cleanouts large enough for easy cleaning. Manholes shall not be used for catch basins or yard drains.
- .2.3 Manholes shall be provided and shall be not more than 250 feet apart, except for large or very deep sewers. Lids shall be properly identified with cast-in lettering, indicating "STORM SEWER" or "SANITARY SEWER". Use the City of Columbus Construction and Material Specifications, State of Ohio Department of Transportation (ODOT) Construction and Material Specification Item 207, and/or local codes for minimum requirements.
  - .2.3.1 Each manhole or catch basin that meets the OSHA definition of a confined space shall have an entry opening that measures 30" or larger in diameter or 30" or more on a side.
  - .2.3.2 Steps or ladder rungs shall be built into manholes, catch basins, pits, and vaults as appropriate to provide foot and hand holds.
- .2.4 Sewers shall be laid on a uniform grade from manhole to manhole. Double strength sewer tile shall be used when overburden is heavy or when sewer runs under roads. Sewers shall be extra heavy cast iron where buried under traffic areas with less than 3 feet of cover. Compression joints conforming to ASTM C-425 "Compression Joints for Vitrified Clay Bell and Spigot Pipe" shall be used on clay sewer pipe.
- .2.5 Cleanouts shall be provided on all downspouts before they enter the ground.
- .2.6 Joint Treatment: Caulked joints in soil pipe shall be caulked with white oakum and lead. The use of gaskets on joints as noted in paragraph 22 10 05.8 is acceptable. Lead shall not be used for caulking of joints in waste and vent lines where mercury might be used.
- .2.7 Floor Drains: In general, floor drains shall be provided in toilet rooms and in equipment and fan rooms. These drains shall not be placed in ducts or plenums, or places of negative air pressure. (This is to avoid drying traps and pulling sewer gas into the air system.) Floor drains with sediment bucket shall be provided in trash rooms serving kitchens. In emergency shower and eyewash areas, floor drains must be discussed with the University Architect.
- .2.8 Equipment Drains: Specify extra deep traps in locations subject to high pressure or vacuum such as fan housing, etc., to avoid loss of trap seal.
- .2.9 Drip Lines from pumps, automatic traps, automatic air vents and from equipment shall be located to discharge over adjacent floor drains. Drip lines from pumps shall be connected to stuffing box drip points, not at drip base of pump. A separate drip line from drip base to over adjacent floor drain shall be provided.
- .2.10 Flashing shall be provided for each vent. Flashing shall not be less than 4 lb. sheet lead and shall extend up and turn down inside top of vent. Specifications shall call attention to the requirement for coordination with the installation of roofing.

## DIVISION 22 – PLUMBING

---

- .2.11 The Manufacturer's Detailed Instructions for the installation of acid waste and vent lines shall be included in the final specifications submittal.
- .2.12 Acid Neutralizing Sumps: Provide as required. Locate sumps for servicing ease.
- .2.13 Glass waste piping under slabs or underground is prohibited.

### 22 40 00. PLUMBING FIXTURES

- .1 FIXTURES AND APPURTENANCES: Fixtures shall be of standard types and design and shall be selected on the basis of providing low flow rates of water, either by design or by the installation of flow restrictors. Principal fixture consideration should be given to showerheads and faucets.
- .2 GENERAL PROVISION: Include in the specifications a statement that, during final inspection of the buildings, the contractor will be required to remove at least one randomly selected water closet in the presence of designated University personnel so that it can be checked for proper installation. If the one water closet is found to be installed in a defective manner, the contractor will be required to remove and properly reinstall all water closets.
- .3 DETAILS:
  - .3.1 Urinals and Water Closets: Siphon jet or blowout type urinals shall be used except where sound control is a problem. Water closets shall be elongated design with open front seat, color as approved by the University Architect's Office.
  - .3.2 Janitors' mop sinks shall be precast terrazzo or molded stone (24 inch by 36 inch minimum), with a front edge stainless steel cap, on the floor.
  - .3.3 Individual Electric Refrigerated Water Coolers shall be provided in new buildings. Wall hung types are preferred. The Associate shall determine the location of coolers for use by persons with disabilities and shall make adjustments in the building structures to assure accessibility to coolers by persons in wheelchairs. Water consumption shall not pass through, around or near lead of any form or sort.
  - .3.4 Shower Mixers shall be thermostatic mixing type.  
**Student Life: Require pressure balance with positive stops to be used for showers.**
  - .3.5 Built-up Shower Pans shall be detailed in the drawings and specified.
  - .3.6 Traps on Lavatories and Sinks shall be not less than 1-1/4 inch by 1-1/2 inch chrome plated cast brass "P" traps with brass nut.
  - .3.7 Supplies to Lavatory Fittings shall be flexible tube risers with steel handle stops, all chrome plated.

### 22 42 05. FIXTURE CARRIERS

- .1 FIXTURE CARRIERS: Lavatories, urinals, wall hung sinks, electric water coolers, and wall hung water closets shall be supported by chair carriers strongly anchored to withstand abusive eccentric loadings.
  - .1.1 Closet Chair or Carrier shall be selected so that the stud plate is supported by the wall back of the fixture. (It is important that this plate be against the wall to provide a rigid mounting.)

## **DIVISION 22 – PLUMBING**

---

- .1.2 Carriers shall be firmly anchored to the floor with maximum sized bolts that the feet will accommodate. Remember that people stand and bounce on fixtures so solid anchorage is imperative. Provide a template for bolts through the wall.
- .1.3 Neoprene gaskets shall be used.
- .1.4 The stud or nipple on the carrier shall be adjustable without cutting or defacing the wall and still maintain a tight joint.

### **22 70 00. SPECIAL SYSTEMS:**

#### **22 70 10. COMPRESSED AIR**

- .1 Refer to paragraph 22 70 10.4 for requirements for air compressors.
- .2 AUTOMATIC CONDENSATE TRAPS shall be provided at all air receiver tanks and low points on compressed air line.
- .3 COPPER PIPE shall be used where there is likelihood of rust or of dirt in the air.
- .4 COMPRESSORS:
  - .4.1 Vibration isolation: Refer to paragraph 22 05 50.
  - .4.2 Air compressors (10 hp and under) shall be air cooled. Caution shall be exercised in locating compressors, with respect to heat producing equipment and room ambient temperature.
  - .4.3 Refrigerated coolers shall be used on air supply to building air control systems or equipment. If intake is extended, provide for easy maintenance.

#### **22 70 20. AIR AND GAS PIPING SYSTEMS**

- .1 COMPRESSED AIR AND GAS PIPING: See 22 00 05, 22 00 09, 22 10 05.6, 22 10 05.7, 22 70 10.4, and 22 70 30.
- .2 GAS BURNING EQUIPMENT: All gas burning equipment shall comply with the local gas company requirements, the State Code, and the City Code. Devices burning 20,000 Btu per hour or more shall be vented to the outside. Where applicable, appliances shall carry the AGA stamp. All such devices shall have approved safety pilots.
- .3 LARGE GAS BURNING DEVICES (such as boilers, incinerators, ovens, and kilns over 50,000 Btu) shall comply with Factory Mutual or Industrial Risk Insurance recommendations. In buildings of high occupancy, Industrial Risk recommendations shall be followed.

#### **22 70 30. GAS PIPING:**

- .1 Piping shall not be run under buildings or basement floors. Double pipe with a vent shall be used where piping passes through an outside wall of a building or tunnel or under pavement other than normal sidewalk. Piping shall not pass through plenum chambers.
- .2 INTERIOR PIPING: An insulating flange shall be furnished and installed at the point of service entrance, to electrically isolate interior and exterior piping.
- .3 CONCEALED PIPING shall be welded.

## **DIVISION 22 – PLUMBING**

---

- .4 REGULATORS: Properly vent to the outside where required by code or for safety.
- .5 PIPING SHALL ENTER BUILDING ABOVE GRADE. Wall shall be sleeved and caulked at entrance.

END OF DIVISION 22 - PLUMBING

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

2006 Edition, Published January 1, 2006; Division Revision Date: February 7, 2017

### **23 00 00. HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

*[Commentary: Note: Division 23 applies to piping and valves, etc., within buildings. For piping and valves external to buildings (campus district heating, district cooling, natural gas, etc., Division 33 applies. For buildings connecting to campus utilities, review with OSU Project Manager where Division 33 applicability stops and Division 23 starts.]*

### **23 00 03. GENERAL PROVISIONS**

- .1 Specialized exhaust systems will need to be provided for offset printing and dark room operations. Refer to Appendices for laboratory ventilation and fume hood exhaust air systems.
- .2 COHESIVE DOCUMENTS OF BUILDINGS, UTILITIES AND SYSTEMS: The A/E's design documents shall provide one-line diagrams of all utilities, organized in relation to the new construction plus the existing construction. Provide one-line diagrams of each system, organized in relation to the new construction plus the existing construction. The one-line diagrams and system documents must display the interrelationship of all systems with all attributes of the building (number of floors, future or shelled-out spaces, original buildings, added building areas, etc.).
- .3 All electrical equipment provided by the HVAC contractor shall be in accordance with the requirements of Division 26.
- .4 All equipment provided by the HVAC contractor that is furnished with fuses shall be provided with spare fuses in accordance with Division 26.
- .5 ROTATING EQUIPMENT
  - .5.1 GENERAL PROVISIONS: Where possible, specify rotating equipment with antifriction sealed spherical ball or roller bearings, split pillow blocks, and lubrication of bearings in accordance with manufacturer's recommendations before start-up. Bearing life (on equipment 5 hp and larger) per Anti-Friction Bearing Manufacturers Association rating procedures shall be 90 percent expectancy of reaching at least 87,360 hours under design conditions. Caution the contractor to exercise extreme care in cleaning and lubrication of bearings after equipment has been subject to prolonged periods of storage before operation. The contractor shall be made responsible for continued lubrication of equipment until acceptance of his work.
  - .5.2 NOTIFICATION OF START-UP: The A/E shall notify the OSU Project Manager of the schedule for start-up of all equipment.
  - .5.3 REPORT REQUIRED: The A/E shall specify that the Contractor, at the time of acceptance, shall provide the OSU Project Manager with a report listing the following:
    - .5.3.1 Dates equipment arrived at job site.
    - .5.3.2 Installation completion date.
    - .5.3.3 Dates of maintenance at start-up and periodic inspections.
    - .5.3.4 Dates of lubrication, specific brand names, manufacturer and type(s) of lubricant.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

.6 EQUIPMENT IDENTIFICATION: Specify that fans, controls, switches, ventilators, pumps, and other items of equipment, which have had the manufacturer's data tags removed or rendered illegible, be equipped with new tags by the installer. Tags shall be brass plates on which operational data plus information regarding areas or other equipment served is stamped. Permanently attach tags to the equipment in locations where they can easily be read.

23 00 05. SUBMITTALS:

.1 FOR DESIGN CONSIDERATION:

.1.1 Refer to Part One of the Building Design Standards.

.2 FOR PROJECT CLOSEOUT:

.2.1 Refer to Part Two of the Building Design Standards.

23 00 07. TESTING

.1 TESTING PROCEDURES

.1.1 Testing Procedures: Specify that all tools, instruments, and equipment required for performing tests be furnished and that required temporary connections be made. Defects that develop under tests shall be repaired promptly and the tests shall be repeated. No caulking of screwed joints, cracks, or holes will be permitted. Leaks shall be repaired by tightening joints or by replacing pipe, fittings, or equipment with new materials. Minor leaks in welded joints may be chipped out and rewelded.

.1.1.1 Hydrostatic and air tests shall be made before piping is concealed or covered. Specify that systems be completely drained after hydrostatic tests are performed and that damages caused by freezing, prior to acceptance of the completed installation, be repaired at no cost to the University.

.1.1.2 Preparation for Testing: Prior to testing, obtain satisfactory operation and uniform temperatures; perform air and water balancing and adjustment of pressure reducing stations and HVAC equipment. Pressure reducing valves, relief valves, air vents, and motor-operated valves shall be checked for proper operation. Pumps shall have operating heads adjusted in accordance with the performance curves; test reports shall include amperage readings.

.1.1.3 Water Chiller and Boiler Check Out: Specify that a factory-trained serviceman employed by the manufacturer perform adjustments, start-up, tests, and provide syllabus-of-training plus instructions to designated University operating personnel. Training by the manufacturer shall be coordinated with the OSU Project Manager.

.1.1.4 Refrigeration piping shall be isolated from the refrigeration system and tested in accordance with ASHRAE 15. Perform tests at an ambient temperature above 50 degrees F.

**DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .1.1.5 Testing of service lines shall follow recommended code practices. When lines are tested with water pressure, care must be taken to remove all air to avoid false pressure readings.
- .1.1.6 Refrigerant piping shall be tested independent of existing piping systems and existing or new equipment.
- .1.1.7 Underground and buried lines shall be tested for a period of 24 hours at one and one-half times the normal working pressures. Lines shall not be tested against existing systems. Water lines may be tested in accordance with AWWA, if the test procedure is outlined and approved.
- .1.1.8 Conduit for underground thermal lines shall be tested with air at not less than 15 pounds pressure for a period of twenty-four (24) hours. Piping in the distribution system shall be subjected to a hydrostatic test pressure of 250 psig or twice the working pressure whichever is greater.
- .1.1.9 Pressure and Duration of Tests: Exposed lines shall be tested with the test fluid at pressures indicated for a period of not less than 6 hours and shall show no drop in pressure:

Line	Test Fluid	Pressure Not Less Than
Steam - 200 lbs.	Water	300 lbs.
Steam - 100 lbs.	Water	200 lbs.
Steam - 15 lbs.	Water	125 lbs.
HWS & HWHR	Water	125 lbs.
Chilled Water	Water	125 lbs.
Condensate	Water	125 lbs.
Condenser Water	Water	125 lbs.
Air	Air	150 lbs.

- .2 BALANCING: Specifications shall make recommendations for balancing of air and water systems and shall stipulate that the Balancing Contractor shall be a company certified by the Associated Air Balance Council (AABC), National Environmental Balancing Bureau, Inc. (NEBB), or other nationally recognized authority to perform tests, and shall be certified in the disciplines specific to the project applications and needs. The balancing contractor shall be hired by the A/E, except for Design-Build projects, where the balancing contractor shall be hired by the Criteria A/E.

*[Commentary: The University desires that Testing, Adjusting, and Balancing results be verified independently of the HVAC Contractor and of the A/E for Design-Build. The TAB contractor may be hired by the HVAC Contractor, Construction Manager, A/E, or Criteria A/E for any project with TAB verification by an independent Commissioning Authority under contract with the University. ]*

- .2.1 Prebalance Meeting: At a date determined by the OSU Project Manager, a prebalance meeting will be scheduled with the balancing company, designated University personnel, the A/E, and his engineering consultants, and contractor to review the system or systems involved. During the meeting, it shall be determined whether the system or systems will be balanced for full cooling, full heating, or modulated as applicable to both design and weather conditions. In preparation for this meeting, the company selected to perform the system balance shall be required to review the project drawings and, within 30 days, submit to the A/E a summary of proposed methods of test procedure for each



## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

system and indicate if any changes are required to permit balancing. Proposed tests shall include, but not be limited to, the following:

- .2.1.1 Testing of hot and cold mixing dampers.
- .2.1.2 Testing and setting of balancing dampers.
- .2.1.3 Testing total C.F.M., S.P., R.P.M., O.V., and B.H.P. of all fans.
- .2.1.4 Testing air and water velocities at coils. Describe test conditions and procedures.
- .2.1.5 Deleted.
- .2.1.6 Testing ducts and air shafts for leakage. Duct leakage testing shall be per ASHRAE 90.1-2007. **Student Life requires that equipment also be leak tested.**
- .2.1.7 Testing and adjusting of variable air volume systems and the tracking of supply air fans with return air fans at the following normal extremes of system operation:
  - .2.1.7.1 Maximum volumes, i.e., maximum summertime cooling design volumes, with constant volume toilet exhaust in operation.
  - .2.1.7.2 Minimum volumes, i.e., minimum wintertime heating design volumes, with constant volume toilet exhaust in operation.
- .2.1.8 Prior to any hydronic balancing, the following must first occur. The hydronic systems shall have been circulated and shall be determined to be internally clean and leak-free. The hydronic system contractor shall open all hydronic strainers, remove the strainer from the strainer fitting, throw away the start-up strainer, clean the permanent strainer, re-insert the permanent strainer, and remove all air from the water system. The balancing contractor may then perform the hydronic balance.
- .2.2 Conducting the balance: The balancing company will coordinate with the Contractor to adjust equipment or to arrange for personnel of equipment suppliers to be available for the necessary adjustment at the time of balance. Any discrepancies or items not in accord with contract documents, which may affect the total system or systems balance, shall be reported in writing to the A/E and OSU Project Manager. Air and water balance must be repeated following corrections to confirm that corrections were made.
- .2.3 FUME HOOD BALANCING shall be in accordance with procedures outlined in Appendix. Coordinate balancing with OSU Environmental Health and Safety through the OSU Project Manager.
- .2.4 REPORTS: One copy of the preliminary air and water balance report is required. One hard copy and one electronic copy of the final balance reports indicating specified and actual tested conditions, including verification of equipment performance, as well as explanation for variation from specified conditions shall be submitted to the OSU Project Manager.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

*[Commentary: The A/E should determine the level of effort desired based on individual project needs when specifying verification of performance (e.g., will testing and demonstration of design capacity for chillers, cooling towers, boilers, etc., be required?).]*

### **23 05 05. HVAC SPECIALTIES**

#### **23 05 19. GAUGES AND THERMOMETERS**

.1 METERS: Refer to Division 33

.2 GAUGES:

.2.1 Gauges other than draft gauges shall be 4-1/2 inches diameter single spring type with recalibration adjustment in the dial face and with ball valve shut-off. Tailor the range to the application. Gauges shall not be positioned over 6-feet above the floor; install remote sensing gauges as required to conform to this restriction. Gauges shall be applied on all pumps, strainers, and air handler coils. Provide separate gauges on inlet and discharge. Do not use a single gauge with a valved manifold. Gauges shall include snubbers and/or siphons. Gauges in applications with possible dirty strainers shall include compound-ranges.

.2.2 Draft gauges in systems of more than 5000 cfm shall be installed across all pre-filter/intermediate filter systems, across after-filters and across low efficiency filters. Below 5000 cfm install magnehelic type gauges.

.2.3 Pressure gauges, at compressors of over 100 Ton capacity, indicating high side, low side and oil pressure shall be provided, if they are not included as a part of the compressor package.

.2.4 A steam gauge with syphon after regulators (within sight of the regulator but at a suitable distance downstream from the regulator to assure good pressure readings) shall be provided to enable operating personnel to properly adjust the regulator.

.2.5 Other piped systems: Locate vacuum or pressure gauges as required to properly identify pressure within each system.

.3 THERMOMETERS:

.3.1 Thermometers shall be mercury-free blue or red-reading-in-glass type with 9-inch magnified column, Fahrenheit scale, recalibration feature, adjustable head and brass separable socket. Tailor the range to the application. Thermometers shall not be positioned over 6-feet above the floor; install remote head type of thermometers as required to conform to this restriction.

.3.2 Where appropriate to the application, consider using light-powered, digital thermometers with Fahrenheit scale, recalibration feature, adjustable head, brass separable socket, LCD with minimum 3/8-inch characters, high-impact ABS or cast aluminum case, and glass-passivated thermistor. Minimum range shall be minus 40 to plus 300 degrees F. Minimum ambient operating range shall be minus 30 to plus 140 degrees F. Thermometer shall have a lux rating of 10 lux (1 footcandle) and require no batteries.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .3.3 Piped systems and storage tanks: Locate thermometers as required on all systems or tanks where temperature should be identifiable for operation and maintenance. Suggested applications include hot water converters, domestic water heaters, water tempering stations, air handler heating coils, air handler cooling coils, chiller and condenser water systems, etc.
- .3.4 For each temperature sensor well location, also install a thermometer well and thermometer to allow verification of the sensor reading.

### 23 05 25. VALVES

**[Commentary:** For steam and steam condensate valves, the A/E shall review the type of connections (welded, flanged, or screwed) and the type of isolation valves (gate or high-performance butterfly) desired with the OSU Project Manager. This could vary depending on the shop responsible for maintenance.]

- .1 PROPRIETARY BRANDS: All valve-types furnished on a project shall be products of one manufacturer for each type of valve specified. List 3 (minimum) manufacturers of equal products from which the contractor will make a selection.
- .2 TYPES: Specify the following valve-types for installations indicated:
- .3 VALVES IN STEAM LINES (150 psig and above):
  - .3.1 Gate valves 2 inches and smaller: Use Division 33 valve 3GT10W, with socket weld or threaded ends.
  - .3.2 Gate valves 2-1/2 inches and larger: Use Division 33 valve 3GT20W, with butt weld or flanged ends.
  - 3.3 High-Performance Butterfly valves: use cast steel, Class 300, flanged rotary valves, suitable for bi-directional shutoff, dead-end steam service at 250 PSIG and 650 degrees F. Specify metal-seated, quarter- turn, triple-offset type valve with the following construction and characteristics:
    - .3.3.1 .Suitable for installation above ground or in steam vaults.
    - .3.3.2 Body: WCB carbon steel; double-flanged body construction, ASME/ANSI B16.5 class 300 flanges.
    - 3.3.3 Seat: Stellite or similar hard surfaced material.
    - .3.3.4 Resilient, non-flexing laminate metal seal composite of stainless steel and graphite retained such that centering movement is permitted.
    - .3.3.5 Retainer screws, disk, and plate shall be stainless steel.
    - .3.3.6 Shaft shall be single piece construction.
    - .3.3.7 Per ANSI B 16.5, 31, 34 construction for body components B31 .1, 31.3 ASME section VII, IX.
    - .3.3.7 Valves shall meet API 607 Rev.4 standards.
    - .3.3.8 Hardened bearing with bearing seal shall be retained in body.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .3.3.9 Shaft seal shall be graphite with multiple stud packing gland follower for adjustability utilizing Belleville style washers.
- .3.3.10 Right angle gear with 2 in. AWWA nut, with loose steel hand wheel or chain wheel attachment, for remote “tee” handle operation (identify which operator on drawings).
  - .3.3.11 Rotary valves for services requiring insulation shall be equipped with stem housings of suitable length to clear insulation.
  - .3.3.12 **INSTALLATION:** Do not use gaskets for resilient seated valves unless instructed by the manufacturer.
- .3.4 Above 15 psig, for steam lines 6 inches and larger, provide a small angle-valve bypass around isolation valve for warmup per OSU Utilities guidelines.
- .4 **VALVES IN STEAM LINES (above 15 to below 150 psig):** Use cast steel, Class 150, bolted flange yoke bonnet, outside screw, rising stem, butt welding or flanged ends 2 inches and larger. Use forged steel, socket welding or threaded ends 1-1/2 inches and smaller. Bodies shall be cast carbon steel conforming to ASTM A216, Grade WDB. Bonnet shall be one-piece cast carbon steel conforming to ASTM A216, Grade WCB. Gasket shall be compressed in the body-bonnet. Valves shall be repackable under pressure. Seat rings shall be threaded.
  - .4.1 Gate Valves: Stem and solid wedge shall be stainless steel #P-140 conforming to ASTM A182, Grade F-6. Seat rings shall be stainless steel #P-140 –15, conforming to ASTM A182, Grade F-6, surface hardened. Stuffing boxes shall have high temperature packing. Condensation chamber shall be provided immediately below packing.
  - .4.2 Globe Valves: Disc shall be stainless steel P-140-15 conforming to ASTM A182, Grade F-6, surface hardened. The seat shall be stainless steel P- 140 conforming to ASTM A182, Grade F-6. The type “S” seat and disc shall have spindle on underside of the disc guided through a bridge cast integral with the seat. Seat ring shall be threaded.
  - .4.3 Check Valves: Swing disc and seat ring shall be stainless steel P-140 conforming to ASTM A182, Grade F-6.
- .5 **VALVES IN STEAM LINES (15 psig and below):** Use bronze or cast iron, 150 lbs. SWP at 500 degrees F, bolted flange yoke bonnet, outside screw rising stem, flange ends 2-1/2 inches and larger; screwed ends 2 inches and smaller. Gate and globe valves shall have Teflon packing. Other construction as specified in paragraph 23 05 25.4.2.
- .6 **VALVES IN HYDRONIC SYSTEMS:**
  - .6.1 Gate valves: Make the same as gate valves in 0 to 15 psig steam lines.
  - .6.2 Globe valves (2 inches and smaller): Use all bronze, threaded, union bonnet, rising stem, 200 lbs. SWP, repackable under pressure.
  - .6.3 Globe valves (2-1/2 inches and larger): Make the same as for 0 to 15 psig steam lines.
  - .6.4 Check valves: Make the same as 0 to 15 pounds steam lines.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .6.5 Ball Valves: 3 inch and smaller, two to three piece bronze body, screwed ends, stainless steel ball, steel stem, reinforced TFE packing and seat ring with appropriate pressure and temperature rating for specific application.
  - .6.6 Butterfly Valves: 2.5-inch and larger, lug type, suitable for bidirectional dead-end service at rated pressure without use of downstream flange; ASTM A 126, cast iron or ASTM A 536, ductile iron, NBR seat, SS stem, SS or aluminum bronze disc, 150 psig CWP rating.
  - .6.7 Isolation shut-off valves with ball-type drain valves shall be provided in major branch lines serving multiple terminal units, risers and branch lines serving each floor that are connected to these risers.
  - .6.8 Lock-shield balancing valves shall be provided at all terminal units and should also be considered for return branch lines connected to multistory risers.
  - .6.9 Blow down valves shall be provided for all strainers.
  - .6.10 Manual air vent valves shall be provided on all convectors, radiators and terminal unit coils.
- .7 **BALANCING VALVES:** Special types of balancing valves may be approved if submitted with detailed information in advance to the University Engineer.
- .7.1 Valves (2 inches and smaller): Use 150 lbs. SWP, all bronze, renewable composition disc, union bonnet, lockshield stem, repackable under pressure, or 175 lbs WOG, threaded brass body, wrench operated ball centric valve suitable for 250 degrees F continuous operating temperature, adjustable stop.
  - .7.2 Valves (2-1/2 inches and larger): make the same as for globe valves in 0 pounds to 15 pounds steam lines; hand-wheel shall be removed and tagged with number of turns that valve is open, or 175 lbs. WOG, flanged iron body, wrench operated ball centric valve suitable for 250 degrees F continuous operating temperature, adjustable stop.
  - .7.3 The University prefers separate balance and shutoff valves. The University prefers that triple-duty valves not be applied. We prefer balancing valves shall be separate from check/shutoff valves. In that way, the setting of the balance valve is more likely to be retained without tamper when any shutoff valve is closed. Consider the cost versus benefit of pressure-independent balancing valves.
  - .7.4 For accuracy of balance readings, the design and the installation must include the manufacturer's recommended upstream and downstream unobstructed distances to obtain reliable flow readings.
- .8 **VALVES IN STEAM CONDENSATE LINES:** A union shall be provided downstream of (and within 12 inches of) each valve.
- .8.1 Steam Condensate valves shall be as specified for valves in steam lines. Class of service shall be based on class of steam upstream (inlet side) of steam trap. For stainless steel condensate return systems, specify Division 33 valve 10GT20F for valves 2-1/2 inches and larger and valve 10BL11W (socket weld or threaded ends) for valves 2 inches and smaller.
  - .8.2 Drain valves shall be ¾ inch gate valves, as specified for valves in water lines, and shall have ¾ inch hose nipple switch caps.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .8.2.1 Nipples shall be of same weight and material as pipe with which they are used, except all close and shoulder nipples shall be extra heavy.
- .8.3 Swing check valves shall be flanged, 250 pounds, semi-steel (ASTM A-126 – Grade B cast iron) body, bronze trim, 1/16 inch raised face.
- .9 VALVES IN HOT WATER HEATING BOILER SYSTEMS: Attention is directed to “Ohio Boiler Inspection Laws and Rules,” relative to valves at boiler connections and in blowdown lines.
- .10 VALVE TAGS: Each valve in each piping system shall be tagged with a brass or aluminum tag numbered consecutively for each system and attached to the valve with a brass or aluminum chain. Valve tags shall have stamped abbreviations of the system in addition to the valve number.

### **23 07 00. HVAC INSULATION**

- .1 GENERAL PROVISIONS FOR FIRE AND SMOKE HAZARD RATINGS: All insulation shall have a system fire and smoke hazard rating as tested by procedure ASTM-E-84, NFPA 255, and U.L. 723 not exceeding: Flame Spread 25 and Smoke Developed 50. The system rating shall be based on insulation, jacket, adhesives, coatings, fittings, and cements. Any treatment of jackets or facings to impede flame and/or smoke shall be permanent. The use of water-soluble treatments is prohibited. ASBESTOS IN ANY FORM OR MIXTURE(S) IS PROHIBITED.

#### **23 07 13. DUCT INSULATION:**

- .1 THERMAL INSULATION: Thickness of supply air duct and plenum insulation shall be selected to prevent condensation on the surface of insulation when the ambient relative humidity is 90 percent at the maximum difference between the ambient air temperature and the supply air temperature. Minimum thickness of supply-air or return-air duct insulation shall be 1 inch nominal, and 2 inches nominal on outside air duct or plenum. Insulation shall be continuous through all openings, but shall be interrupted at fire dampers. The thermal insulation used to cover the ducts shall meet or exceed ASHRAE Standard 90.1-2007 for energy conservation and be asbestos free.
  - .1.1 Exposed rectangular air conditioning supply and return ducts in non-air conditioned space shall be insulated with rigid or semi rigid fiberglass insulation board having a density not less than 3 pounds/cubic feet and with field or factory applied fire retardant glass cloth jacket with vapor barrier. When factory applied facing is used, all insulation joints will be sealed with pressure sensitive joint sealing tape to match the insulation facing.
  - .1.2 Concealed air conditioning supply air ducts in ceiling space above an air conditioned room shall be insulated with fiberglass duct wrap insulation of 3/4 pounds/cubic feet density with factory applied vapor barrier and fire retardant jacket. When insulation is necessary on return air ducts, ducts shall be insulated in the same manner.
  - .1.3 All exposed round air conditioning supply air and return air ducts shall be insulated using either a closed-cell elastomeric sheet or roll insulation, with antimicrobial protection, adhered directly to the duct or a rigid preformed fiberglass insulation with All Service Jacket.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .1.4 Outside air intake ducts and air plenums shall be insulated the same as specified for exposed rectangular air conditioning supply air ducts.

*Commentary: The insulation described above is for “indoor” applications. Installation of “outdoor” ductwork that requires insulation is not a preferred location for the University and requires prior approval by the University Engineer.*

- .2 **ACOUSTIC LINING: INSTALLATION OF INTERIOR DUCT INSULATION (DUCT LINER) IS PROHIBITED.** Exception: Lined ductwork is permitted for transfer ducts connecting adjacent rooms. Sound attenuation for each individual project must be reviewed and is subject to approval by the University Engineer before design is completed.

### **23 07 16. EQUIPMENT INSULATION**

- .1 All pieces of equipment with surface temperatures over 130 degrees F or with temperatures causing condensation at ambient relative humidity of 90 percent shall be insulated. Type and thickness of insulation shall be as specified for piping.
- .2 **INSULATION NOT REQUIRED:** Steam traps, hot water, and condensate return pumps, and hot water expansion tanks shall not be insulated.
- .3 Chilled water pumps are required to be insulated. Insulation may be closed-cell elastomeric, equivalent to Armacell AP/ Armaflex.
- .4 **BOILER BREECHING** shall be insulated with manufacturer-provided, pre-fabricated, factory-insulated breeching. Follow specification to determine the specific operating temperature. Apply appropriate finish jacketing range.

### **23 07 19. PIPING INSULATION:**

- .1 **REQUIRED INSTALLATION:** The following piping shall be insulated:  
Steam and Steam Condensate lines  
Domestic cold and hot water lines  
Exposed Geothermal/Ground Source Heat Pump lines  
Cooling Coil Condensate Drain Lines  
Chilled water lines  
Heating hot water lines  
Refrigerant lines, where necessary  
Fuel oil lines, where necessary or exposed to low temperatures.
- .2 **SPECIFICATIONS:** Maximum temperature limit of the insulation must be above the maximum operating temperature of piping. Surface temperature of insulation for heated piping in still ambient air at 80 degrees F shall not be above 110 degrees F at the pipe operating temperature below 400 degrees F. The minimum thickness of insulation shall be one inch. Thickness of insulation for cold piping shall be selected to prevent condensation on the surface of insulation and ambient temperature is 50 degrees F above the pipe temperature. Specify that insulation be installed with a continuous unbroken and unpunctured factory applied vapor barrier. Insulation shall meet or exceed the current version of ASHRAE Standard 90.1 -- Energy Standard for Buildings Except Low-Rise Residential Buildings for energy conservation.
- .2.1 Piping with an operating temperature of 300 degrees F and above shall be insulated with calcium silicate insulation molded in sections with a minimum of .016 Aluminum jacket.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .2.2 Piping with an operating temperature under 300 degrees F shall be insulated with molded pipe covering composed of fiberglass, resinbonded and factory applied all service jackets. Compression strength at 25 percent deformation shall be 500 pounds per square foot.
- .2.3 Fittings, flanges, unions, and valves, except valves in hot water lines, shall be insulated. Insulation shall be beveled down to unions with all exposed end sealed with CP.10 or equivalent. Insulation covers shall be either prefabricated or fabricated of pipe insulation. Insulation efficiency shall not be less than that of the adjoining piping. Specify that insulation vapor barrier be installed continuous and unbroken.
- .2.4 Hangers, supports, anchors, secured directly to cold surfaces, must be adequately insulated and vapor sealed to prevent condensation.
- .2.5 Rigid insulation inserts of proper length shall be installed between pipe and insulation protection shield to prevent sagging of pipe covering at hanger points. Compressive strength of insulation inserts shall be not less than 350 psf at 10 percent deformation. Specify that inserts be installed as pipe is erected.
- .2.6 Insulated piping lines running outdoors shall have corrugated or plain 0.016 inches aluminum jacket complete with integral longitudinal laps with 2" overlap and butt joint laps with 3" overlap installed in order to shed water. In addition to the vapor barrier, this jacket is required on cold lines.
- .2.7 In service tunnels, pipe insulation shall be covered with PVC jacket secured in place with aluminum straps on 18 inches centers. Sections exposed to heavy mechanical abuse shall have 0.010 inches stainless steel jacket secured in place with stainless steel straps. The lap shall be at least 2 inches on side shedding water and 3 inches overlap on the end.
- .2.8 Piping with calcium silicate insulation and aluminum jacket shall have fiberglass covering between the calcium silicate and the aluminum jacket.

### **23 09 00. INSTRUMENTATION AND CONTROL FOR HVAC:**

- .1 DIRECT DIGITAL CONTROL (DDC) SYSTEM: To achieve precise control of all HVAC systems and to provide the means to integrate standard control functions with energy saving strategies, it is intended that all newly constructed and remodeled buildings on the Columbus campus be controlled using stand alone microprocessor based Direct Digital Control (DDC) computer systems. All hardware, software, and miscellaneous equipment required to insure that the DDC system can be managed from the building and from a remote control center shall be provided as a part of the project. Control centers now in existence are:

- Columbus Campus - Academics and Research – FOD
- Columbus Campus - University Medical Center
- Columbus Campus - Student Life
- Lima Campus
- Wooster Campus
- Mansfield Campus

The A/E shall submit schemes for connecting new facilities to the control center(s). All DDC systems shall be connected to the appropriate control center(s) using the University's fiber optic network, a hard-wired communication trunk, or a telephone



## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

communications trunk, as dictated by the capabilities of the system selected and by the location of the building being controlled.

The control centers in the Columbus Campus (FOD), University Medical Center, Student Life, Lima Campus, Mansfield Campus and Wooster Campus have Central Processing Computers (CPU's) that are compatible with Direct Digital Control. Any expansion in any building within these networks must maintain the integrity of the existing system and allow the new equipment to be controlled by the existing CPU. These locations are to be treated as exceptions and cannot be addressed in the same fashion as an expansion in an area where no CPU exists. The A/E will coordinate this requirement through the University Engineer.

- .1.1 An interconnecting conduit system shall be installed between all DDC panels within a given building. This conduit system shall be extended to the appropriate building exit point to provide the link to the remote communications network. All communications cables required to provide the communications link between the DDC controllers and the external communications network shall be installed as a part of the project. The remote communications link shall be established and remote capabilities shall be verified by the contractor prior to final acceptance of the DDC system.
- .1.2 Schemes shall include necessary provisions in the Plumbing, HVAC, Fire Protection and Electrical construction documents for making system connections. Provisions for DDC Systems are described thoroughly in Appendix A. Also see Communication Wiring Standards in Appendix and Electrical in Division 26.

### 23 09 05. HVAC BUILDING SYSTEMS CONTROL:

- .1 Before design is begun, consult with the OSU Building Automation Shop (FOD, OSUMC, Student Life, or Lima, Mansfield, or Wooster Campus, or other, as appropriate) to determine exact requirements for connection to control centers. In addition to requirements for Direct Digital Control Systems described in Appendix A, the following must be considered in design and installation of equipment.

- .2 **AUTOMATIC DAMPERS:** Automatic dampers which are under proportioning control should be accurately sized in accordance with temperature control manufacturer's recommendations to provide proper mixing and control.

No damper shall have a dimension exceeding four feet or be over 12 square feet in area. Each damper section shall have an individual operator. No linkages shall be installed between dampers to transfer operator power. Manufacturer's catalog information shall be de-rated 50 percent for application to provide positioning of the dampers. Damper operators shall not be of the swing mounting type. They should be mounted outside the air stream where possible, especially in outside air applications. Pneumatic control lines, where they penetrate outside air ducts, shall include dehydrator units. Outside air and return or relief dampers that are automatically controlled shall be of the minimum leakage type.

Quality of dampers shall be specified, including air leakage at 1-inch static pressure when the damper is in the closed position. Provide neoprene edge seals on blades.

- .3 **AIR COMPRESSORS:** Air compressors, when required, shall be provided in the main equipment room for each building. Two compressors shall be provided with the sizes calculated on 50 percent operating time of one compressor to meet the building's compressed air needs. The units' control will include a manual lead/lag control switch. If other compressed air systems are within the building or adjacent to the building,

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

consideration will be given for cross-connecting of the systems. All temperature control air compressors shall be provided with an air dryer.

### **23 20 00. HVAC PIPING AND PUMPS**

#### **23 20 03. PIPING**

##### **.1 GENERAL PROVISIONS:**

.1.1 Submittals for Approval by the University Engineer: Provide three copies each of the following and obtain approval before preparation of final documents.

.1.1.1 Calculations of stresses in steam, hot water, and condensate lines.

.1.1.2 Request for permission to use expansion joints in piping in lieu of bends and/or loops.

.1.1.3 Request for permission to use special materials for condensate piping in lieu of steel pipe with welded fittings. Provide pressure and temperature characteristics.

.1.1.4 Operating pressures and temperatures for grooved pipe mechanical coupling systems if permitted to be used.

.1.1.5 Detailed information on special types of balancing valves.

.1.2 Valve Tags: Specify that each valve be tagged with a brass or aluminum tag numbered consecutively and attached to the valve with a brass or aluminum chain. Valve tags shall have stamped abbreviations of the system in addition to the valve number.

.1.3 Valve Chart: A typewritten directory of valve numbers (by system, describing location) shall be furnished, framed, placed under glass, and installed in equipment rooms, where indicated by the A/E. A copy of the valve directory shall be included in each O-&-M manual, and separate copies of the valve directory, bound in hard fiber binders, shall be delivered to the University Engineer.

##### **.2 DESIGN OF PIPING SYSTEMS:**

###### **.2.1 Prohibited Installations:**

.2.1.1 Condensate drip traps above 15 psig shall not be designed to discharge directly into condensate return mains or condensate pump receivers, but shall be designed to discharge into a flash tank (vented into the low pressure side of the system, if possible), and to drip through a low pressure F. & T. trap to a condensate return main or receiver.

.2.1.2 Bullhead connections in any piping service are prohibited.

.2.1.3 Cast iron, brass and ASTM A120 pipe shall not be used on lines with pressures higher than 49 psig or temperatures higher than 292 degrees F.

.2.1.4 Drain, steam, and condensate lines, and any wet lines (including pipes, fittings, valves, or other), shall not be installed or designed for installation

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

over electrical switchgear, motor control centers, transformers, nor in elevator shafts and equipment rooms.

- .2.2 Provisions for Expansion and Contraction: Steam lines shall be engineered with adequate provisions for expansion and the removal of condensate. The campus steam is distributed at 200 psig and 600 DegF.

Generally, for all campus distribution steam piping outside the buildings, bends or loops shall be used to absorb the pipe expansion and contraction. Particular attention shall be given to proper design of guides and anchors in lines with expansion loops. Expansion joints are not recommended. Approval by the Utilities Division, Facilities Operations and Development is required prior to use of expansion joints.

**OARDC: Steam distribution system is operated at 140 psig and 375 DegF.**

- .2.3 Pipe anchors to control movement of piping shall be shown on drawing. Anchors shall be welded to the pipe, but anchor connection to the building structure must be bolted. Provide structural support and lateral structural support for all kinetic forces.
- .2.4 Vertical risers for hot water and steam lines passing through more than two floors shall have spring support, preferably at the floor nearest to the center of the riser.
- .2.5 Unions shall be provided on piping at the following locations:
- .2.5.1 Adjacent to valves on the downstream side.
  - .2.5.2 At the final connections to items of equipment.
  - .2.5.3 On each side of traps.
  - .2.5.4 Where required for construction and assembling purposes.
- .2.6 Supports: Spacing for the horizontal pipe supports and hanger rod sizes must be specified. Refer to paragraph Facility Services-3.19.2 et al.
- .2.7 Hangers: Where piping is subject to expansion and contraction caused by changes in temperature of carried fluid, adjustable roller hangers or adjustable pipe roll stands shall be provided. Hangers for copper piping shall be copper plated or shall have a suitable lining to prevent electrolysis. Hangers for cold insulated pipe and all roller hangers shall be only outside of the insulation with appropriate "U" support plates to prevent crushing of insulation and to avoid condensation.
- .2.8 Pipe Guides shall be detailed and locations shall be shown. Guide shall consist of a guide spider clamped to the pipe for which movement is to be controlled and a guide casing bolted to a suitable support. Casing shall be of two pieces bolted together by 4 bolts for sizes 3 inches and larger and by 2 bolts for sizes 2-1/2 inches and smaller. The inside diameter of casing shall be larger than the outside diameter of the insulated pipe.
- .2.9 Discharge Piping from all refrigeration system pressure relief devices shall extend, in an approved manner, to the building exterior.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .2.10 Glycol: If glycol is necessary on a new installation, specify propylene glycol. Consider: whether freeze or burst protection is appropriate; need for formulation compatible with aluminum; and automatic makeup system.

### 23 20 05. PIPING MATERIALS:

#### .1 STEAM PIPING (15 psig and below):

- .1.1 Schedule 40, ASTM A-53, Type E or S, Grade B black steel pipe shall be used. Schedule 40 butt welding seamless forged steel fittings shall be used with NPS 2-1/2 and larger pipe. Elbows shall be long radius; flanges shall be 150 pounds class forged steel, welding neck, or slip-on, welded inside and outside. For 2 inches or smaller pipe 125 psig class black cast iron screwed fittings may be used.

#### .2 STEAM PIPING (above 15 psig to 200 psig, temperature less than 600 degrees F):

- .2.1 Schedule 40, ASTM A-53, Type E or S, Grade B Black steel pipe shall be used. Schedule 40 butt welding seamless forged steel fittings shall be used with NPS 2-1/2 and larger pipe. Flanges shall be 300 pounds class. For 2 inches or smaller pipe, fittings shall be socket weld forged steel, 3000 lbs. (minimum) class.
- .2.2 FITTINGS at the CONNECTION TO THE STEAM UTILITY: Show the details for demolition and new construction for piping and connections to the steam utility in the tunnel. Provide a new socket-welded, forged steel, tee-fitting on the existing steam utility in the tunnel, and extend the branch of the tee into the building. It is prohibited to apply a weldolet onto the existing steam utility.
- .2.3 Steam piping above 15 psig within University buildings shall be designed, fabricated, and installed to comply with ASME B31.1. Such piping shall be inspected, examined, and tested per the requirements of Chapter VI of ASME B31.1. A third-party inspector shall be hired by the A/E (Criteria A/E for design-build) and subject to approval by the University.

#### .3 CONDENSATE PIPING: Schedule 40S seamless stainless steel, conforming to ASTM A312 Type TP316L, or Schedule 80 black steel pipe, ASTM A-53, Type E, Grade B shall be used with Schedule 80 butt welding fittings of seamless steel or forged steel socket weld fittings 2000 pounds WOG. Special materials might be approved, upon request, if pressure and temperature characteristics are submitted in advance of design to the University Engineer.

- .3.1 Underground and Tunnel Applications condensate distribution piping requirements: Refer to Division 33.

#### .4 HOT WATER HEATING (HHW) PIPING: Shall be ASTM A53, Gr B, Type E except that lines 4-inch diameter and smaller may be hard copper type L with wrought copper fittings.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .4.1 Fittings 2-1/2 inches and larger: Schedule 40, butt welding seamless forged steel. Elbows: long radius; flanges: 150 pounds SWP, forged steel, welding neck, or slip-on, welded inside and outside, or wrought copper for use with type L copper piping.
- .4.2 Fittings 2 inches and smaller: 125 pounds SWP black threaded cast iron or forged steel welded fittings, or wrought copper for use with type L copper piping. All copper pipe fittings shall be brazed.
- .4.3 Press fittings for copper pipe HHW systems (up to 4-inch diameter) may be used with the approval of the University Engineer. Press fittings made of bronze or copper conforming to ASME B16.18 or ASME B16.22 and performance requirements of IAPMO PS 117. Press fittings shall have factory installed EPDM sealing element and an identification feature on the fitting that provides a visual indication of fittings that have NOT been pressed. Installers of the press fittings shall be certified by the manufacturer.
- .4.4 Press fittings for black steel pipe HHW systems (up to 2-inch diameter), up to Schedule 40 pipe, may be used with the approval of the University Engineer. Press fittings conforming to ASME A420 or ASME B16.3 and performance requirements of IAPMO PS 117. Press fittings shall have factory installed EPDM sealing element and an identification feature on the fitting that provides a visual indication of fittings that have NOT been pressed. Installers of the press fittings shall be certified by the manufacturer.
- .4.5 The use of press fittings for copper or steel pipe systems shall be limited to accessible locations only (not in chases or above inaccessible ceilings).

*[Commentary: In lieu of University Engineer approval, FOD Operations personnel who have received appropriate training may use press fittings with the approval of the Senior Director of Facilities Support or their designee. Note: Do not use press fittings for chilled water systems that are or may be connected in the future to a central campus chilled water plant.]*

- .4.3 Grooved Piping Systems: Grooved piping is prohibited on hot water systems.
- .5 CHILLED WATER SUPPLY AND RETURN: Same as specified for Hot Water Heating Piping.
  - .5.1 Underground chilled water distribution piping requirements:
    - .5.1.1 Outer jacket shall be filament wound fiberglass of recommended thickness.
    - .5.1.2 Insulation shall be hydrophobic type applied in spray process, void free, to the recommended thickness.
    - .5.1.3 Carrier pipe shall be schedule 40, ASTM, Grade B, ERW.
    - .5.1.4 Install per factory specifications.
  - .5.2 Grooved Piping Systems: For chilled water systems, an engineered system of rolled-grooved piping with couplings and gaskets designed for the application may be used with the approval of the University Engineer. Cut-grooved piping shall be specifically prohibited.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .6 CONDENSER WATER SUPPLY AND RETURN: Same as specified for Hot Water Heating Piping.
- .6.1 Grooved Piping Systems: For condenser water systems, an engineered system of rolled-grooved piping with couplings and gaskets designed for the application may be used with the approval of the University Engineer. Cut-grooved piping shall be specifically prohibited.
  - .6.2 For condenser water systems, Schedule 80 PVC piping and fittings may be applied. The PVC shall include UV-protectants, and shall be rated for exterior applications.
- .7 DRIP PIPING FROM PUMPS: Schedule 40 galvanized steel pipe with 150 pounds galvanized banded malleable iron fittings, minimum size 3/4 inch. Run drip piping to floor drain. Hard copper, type L, minimum size 3/4-in., may be used if protected and clamped in place.
- .8 COOLING COIL CONDENSATE DRAIN PIPING FROM AIR HANDLING UNITS: Type "L" hard copper, minimum size 1 inch. Specify that wrought copper fittings with sweat joints of 95-5 solder be used. Trap drain lines and run to suitable drains. Provide cleanouts at traps and in the piping system where pipe changes direction.
- .9 REFRIGERANT PIPING: Dry Seal Type "L" or ACR (Air Conditioning & Refrigeration) nitrogen-charged hard copper. Wrought copper fittings with joints brazed with a 6 percent or higher silver alloy with a 1000 degrees F solidus minimum and comparable to J.W. Harris Co., Inc. "Dynaflow". Copper-steel joints shall be brazed with 55 percent silver alloy brazing materials. Fittings for 5 inches or larger lines shall be tinned cast brass.
- .10 Piping, fittings, and piping accessories manufactured, fabricated, or assembled in China, including Taiwan, are prohibited.
- 23 20 07. UNDERGROUND CONDUIT
- .1 Underground distribution piping shall be factory prefabricated insulated pipe units.
  - .2 CATHODIC PROTECTION: The A/E shall include a soil corrosion analysis, by a reputable company with wide experience in this type of work, and shall specify the installation of cathodic protection, as recommended by the conduit manufacturer to produce the required voltage potential.
    - .2.1 A copy of the analysis shall be submitted to the University Engineer.
    - .2.2 High pressure steam lines may drive out the moisture in the vicinity of steam lines, and may cause cathodic protection to not be required on steam lines. This must be analyzed by the A/E and submitted to the University for approval.
    - .2.3 See Section 22 70 30.5 for schedule of cathodic protection.
  - .3 COORDINATION OF CONTRACT DOCUMENTS:
    - .3.1 Site Work: Underground conduit shall be pitched for drainage and location shall be coordinated with other underground installations. Installation of the conduit shall be scheduled to follow the last heavy grading or heavy equipment traffic. Minimum earth cover shall not be less than 36 inches or as recommended by the manufacturer, whichever is the greater.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .3.1.1 Underground steam or condensate lines shall not be located within ten feet of buried electric lines in any direction.
- .3.1.2 The A/E and Contractor shall submit in writing, for approval by the University, for any earth cover exceeding 12 feet.
- .3.2 Concrete: The following requirements may be specified in either Division 3 or Division 23:
  - .3.2.1 Pipe supports shall be precast of special insulating concrete, steam kiln cured. The outer edge must be corrugated to allow free passage of air and drainage in place.
- .3.3 Pipe Sleeves: Refer to Section Facility Services for requirements.
- .3.4 Anchors shall be installed where shown on the drawings. Anchors shall be steel plates welded to the pipes and steel conduit. Anchor plate shall be embedded in concrete cast over the plate, in accordance with manufacturer's recommendations.
- .4 BASIC MATERIALS:
  - .4.1 Conduit shall be not less than 10-gauge steel designed for proper strength to prevent deformation in service. Interior and exterior surfaces shall be given a hot-dipped galvanized coating. Exterior finish coat shall be a minimum thickness of 20 mils consisting of two alternately applied layers of glass cloth in epoxy resin. Final outside coating shall be capable of maintaining dielectric strength of 5,000 volts. Conduit shall be tested for tightness at 15 lbs. per square inch air pressure before coatings are applied.
    - .4.1.1 Fittings shall be completely prefabricated.
    - .4.1.2 Conduit closures complete with pipe insulation shall be furnished by the conduit manufacturer. Closures shall be of 10 gauge steel with a single horizontal side split and shall be finished with prime coat and one finish coat (inside and outside) of epoxy resin.
  - .4.2 Materials, Other than Steel: Fiberglass or other materials may be used if specific approval is obtained from Facilities Operations and Development. Use of these materials shall be limited to piping systems having a maximum temperature of 212 degrees F and a maximum pressure of 60 psig.
- .5 UNDERGROUND CONDUIT: Install under the supervision of a capable factory trained field engineer in the direct employment of the conduit manufacturer.
- .6 SYSTEM TESTING: The conduit manufacturer shall certify in that his field engineer has witnessed the satisfactory tests on pipe and conduit.
  - .6.1 Hydrostatic Test: All piping in the system shall be subjected to a hydrostatic test pressure of one and one-half times the working pressure per ANSI B 31.1 Power Piping Code.
  - .6.2 Air Test: System shall be subjected to a 15 pounds per square inch air test; any leakage disclosed shall be made tight before backfilling.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .6.3 Spark Test: The entire system shall be subjected to a final spark test prior to backfilling. Any electrical leaks or other physical damage shall be repaired.

### 23 20 09. PIPING SPECIALTIES

- .1 GASKETS: Where flanges must be used, gaskets shall be of materials suitable for use at temperatures and under conditions encountered in the system. Gaskets on steam lines, with pressures of 50 psi gauge or over, shall be wound stainless steel and appropriate composition gaskets.
- .2 AIR VENTS:
  - .2.1 AUTOMATIC AIR VENTS with isolation valves shall be installed at the high points of all hydronic piping, and at all points where horizontal flow goes to vertical down flow. Vents with visual drain shall be specified. The discharge drain shall be extended to a suitable floor drain.
    - .2.1.1 Automatic air vents shall be applied on hydronic systems employing a diaphragm-type expansion tank (i.e., a tank having air and water surfaces separated by a flexible membrane).
  - .2.2 AN AIR CHAMBER with manual vent shall be provided at high points on lines above finished ceilings and in areas where a safe and suitable drain point is not readily available. Provide a flexible drain line.
  - .2.3 Manual air vents shall be used on systems employing a diaphragm-less compression tank, if the air and water surfaces are in direct contact with each other.
- .3 STEAM TRAPS: Traps shall be installed at least 24 inches below steam heating devices to assure adequate draining of the coils. Valves, strainers, and unions or flanges shall be provided upstream of traps.
  - .3.1 INVERTED BUCKET TRAPS: On saturated drips, regardless of steam pressure, inverted bucket traps (IBT's) may be used.
  - .3.2 BIMETALLIC TRAPS: On superheated drips at 50 psig or greater, use bimetallic traps (BMT's). Suggested for consideration are Armstrong SH-250 or Bestobell DM25.
  - .3.3 THERMODYNAMIC TRAPS: On superheated drips at 49 psig or less, use thermodynamic traps (TD's).
  - .3.4 FLOAT AND THERMOSTATIC TRAPS: On any modulating application such as hot water converters, steam heating coils, steam humidifiers, or any other modulating application, use float and thermostatic traps (F&T's).
- .4 VACUUM BREAKERS AND AUTOMATIC AIR VENTS shall be provided on all steam heating coils with modulating valves or automatic on-off valves.

### 23 20 11. PIPING INSTALLATION:

- .1. INSTRUCTIONS TO BE INCLUDED IN THE SPECIFICATIONS: The following instructions to the contractor should be included in the applicable paragraphs. These instructions must be edited to suit the work.



## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .2 DIELECTRIC CONNECTIONS: In water lines where dissimilar metal pipes connect to one another, use dielectric nipples or flanges with dielectric gaskets to counteract electrolysis. All piping and piping accessories shall be suitable for the working pressures and temperatures of the lines in which they are installed. Do not install dielectric unions.
  - .3 WELDED CONNECTIONS:
    - .3.1 Stamped Welds: Welders on pressure piping shall be certified and shall carry their certification and stamp with them. Welds on lines with pressures above 125 psig shall be stamped.
    - .3.2 Items Requiring Welded Connections: Weld steel piping 2-1/2 inches and larger. Weld steel piping installed above finished plaster ceilings and in pipe chases. Weld steam condensate pipe except at 2 inch and smaller threaded connections to equipment and traps.
    - .3.3 Welded Fittings (see piping specifications 23 20 05 for specifications of fittings)
  - .4 BRANCHES: "T" or "Y" forged branch connections or reducing tees are acceptable for branch connections to mains 2 inches diameter or larger. Design all other branch connections with main size tees and eccentric reducers or reducing tees. Branch piping shall not be welded directly to mains. Drip legs in steam lines shall be made with steam line size tees. Eccentric reducers shall be used for pipe size changes with bottom of steam line level, bottom of condensate return lines level, and top of hydronic waterlines level.
  - .5 VIBRATION ISOLATION shall be provided on chilled and condenser water supply and return piping at all compressors.
- 23 20 13. PUMPS:
- .1 GENERAL PROVISIONS:
    - .1.1 COUPLING ALIGNMENT: The University requires that the final coupling alignment be documented and the results furnished in writing to the University Engineer. Field check all alignments and report the maximum angular and eccentric misalignments to the nearest 0.001 inch.
      - .1.1.1 Align coupling flanges for concentricity to assure that the face and curved edges are concentric within the manufacturer's recommendations.
      - .1.1.2 Align coupling for angular alignment to tolerances recommended by the manufacturer.
      - .1.1.3 Align coupling for parallel alignment. On large equipment, subject to heat conditions, alignment must be done in the hot condition.
    - .1.2 SHOP DRAWINGS AND PUMP PERFORMANCE CURVES: Reference should be made to Division 1 for instructions for submittals of shop drawings. Submit performance curves with shop drawings.
  - .2 PUMPING SYSTEMS DESIGN:
    - .2.1 A PRIMARY-SECONDARY PUMPING SYSTEM is preferred where practicable.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .2.2 DESIGN PUMPING SYSTEMS so that the engineer-designed net positive suction head available (NPSHA) at the pump intake will be larger than the (manufacturer-required) net positive suction head required (NPSHR) at the highest possible water temperature at the pump intake.
- .2.3 THE PUMP CURVE REPRESENTING FLOW-HEAD RELATIONSHIP shall intersect the system curve at design operating point. Pumps shall be selected to operate at an efficiency of not less than 90 percent of the maximum efficiency. Maximum total pump head at the no flow condition shall be specified.
- .2.4 FRICTION HEAD CALCULATIONS FOR CHILLED WATER SYSTEMS shall be based on the friction loss standards of the Hydraulic Institute in new pipe. For steam condensate (pumped and gravity) and hot water heating systems, base on friction losses in 15 years old pipe. The A/E may submit for approval by the University of use other sizing standards, such as ASHRAE, Cameron, or Bell & Gossett.
- .2.5 PUMP MOTOR shall be selected and specified as non-overloading over the entire pump curve shown by the manufacturer.
- .2.6 ALL PUMPS shall be installed with line size isolation valves on both sides.
- .2.7 Power Factor Correction: Motors (drives) 50 hp and larger shall be provided with fused, switched, power factor correction capacitors sized to correct to 100 percent or greater. It is preferred that the units be connected between the contactor and overload coils. Units shall meet all fire codes and not be an environmental problem.
- .2.8 Motor and impeller speeds shall be 1750 RPM or 1150 RPM. 3600 RPM selections are prohibited unless approved by the University Engineer.
- .3 CONDENSATE RETURNS: Electric condensate return systems are preferred. Steam-powered condensate return systems require prior approval by the University Engineer. When pumps must be used, specify packaged duplex units, shipped assembled as a complete factory unit with cast iron receiver.
  - .3.1 LEAD-LAG ALTERNATOR for pumps shall be automatic with a manual over ride. Electrical float switch shall bring on the second pump if the flow is too great for one pump. Audible alarm shall be activated when either pump fails.
  - .3.2 Condensate return pumps shall be limited to no greater than 1800 rpm.
- .4 PUMP TYPES
  - .4.1 IN-LINE PUMPS: In-line pumps shall be connected directly to the piping. Motor shall not be separately supported except for large pumps specifically designed for such support. Pumps shall not be mounted with motor shaft vertical unless special thrust bearings are provided. Provide gauge valves at in-line pump suction and discharge. Locations for installation of in-line pumps shall not be obstructed by overhead or beneath equipment or services, such that the pump can be easily maintained and/or removed.
  - .4.2 BASE-MOUNTED WATER PUMPS: For primary pumping application, split case centrifugal pumps are preferred over the end suction pumps.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

.4.2.1 MECHANICAL SEALS are preferred and should be used where adaptable. Complete flushing arrangement shall be provided for mechanical seals and packing.

.4.2.1.1 Horizontal split case pump ball bearings shall be double row on outboard. Pump casings shall have vent and drain plugs and pressure gauge tapping.

.4.2.2 PUMP AND MOTOR shall be installed on a common steel or cast iron base, isolated from the building structure so that the unit will not transmit vibration to the building (concrete inertia base, CIB). Pump coupling to motor shall be flexible. Coupling shall be equipped with a guard.

.4.2.3 PIPING CONNECTIONS to pump shall be flexible to reduce vibration transmission. The flexible connection shall not be used to correct for piping misalignment. Provide separate valved pressure gauges, mounted at the same elevation, for pump suction and discharge.

.4.3 TURBINE PUMPS: Regenerative turbine pumps may be utilized on clean liquid applications. Pump shall have both inboard and outboard bearings. The motor shall be 1750 RPM and shall be sized to prevent overloading at the highest head conditions when the flow of liquid is shut off. Impeller shall be hydraulically self centering. On larger turbine pumps 5 hp and over, a relief valve may be used on the pump to avoid overloading the motor at shut off conditions.

### **23 25 13. WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS:**

.1 Cleaning, Flushing and Water Treatment guidelines can be found in BDS Appendix G-1.

*[Commentary: The Guideline is intended to provide the A/E with general procedural information. The wording in the Guideline is not mandatory; however, the procedure is mandatory for all Closed-Loop Hydronic Systems.]*

### **23 30 00. HVAC AIR DISTRIBUTION**

#### **23 30 05. AIR HANDLING UNITS WITH AND WITHOUT COILS:**

.1 CONSTRUCTION: Central station air handler units shall be of sectionalized construction, consisting of fan section, coil section, and drain pan to catch all condensate. All condensate drain pans shall be aluminum or stainless steel. Galvanized steel, plastic or fiberglass pans are not permitted.

.2 MULTI-FAN UNITS: Selection of a multiple-fan wheel housing assembly in a common fan section (multiple fan wheels on a common shaft or multiple fans operating in parallel) is subject to the approval of the University Engineer. Note: University Engineer approval is not required for a “fan wall” assembly (array of modular, direct-drive, plenum fans).

.3 FAN WHEELS AND HOUSINGS shall be AMCA Class II construction; except, high velocity systems requiring total fan static pressure over 4 inches shall use Class III fans. Medium and high velocity draw-through and built-up systems shall have duct discharge sections designed per accepted good practices to minimize losses and for velocity energy recovery. Minimum length of transition shall be equivalent to one wheel diameter.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .4 CONDENSATE LINES from drain pan must have deep traps to prevent either draw or blow through conditions.
- .5 INTERIOR SURFACES, as well as the division panel separating the hot and cold deck, shall be insulated with not less than 1 inch thick fiberglass blanket. The drain pan shall be insulated preferably on the exterior; however, interior insulation, if provided, shall be of a type that will resist mechanical damage and deterioration by water. All condensate drain pans shall be aluminum or stainless steel. Galvanized steel, plastic, or fiberglass pans are not permitted.
- .6 FACE AND BY-PASS DAMPERS AND ZONE DAMPERS shall have bronze or nylon bearings with non-slip spline and rib connections between damper blades and mounting rods. Zone dampers shall have neoprene gaskets for blades to seal against entire stop.
- .7 MISCELLANEOUS DETAILS:
  - .7.1 Solid shafts shall be specified. All shafts will be provided with machine centers.
  - .7.2 Wheels shall be of heavy gauge riveted or welded design.
  - .7.3 Wheel hubs shall be machine bored with full line contact on solid shaft.
- 23 33 00. AIR DUCT ACCESSORIES
  - .1 FIRE AND SMOKE DAMPERS:
    - .1.1 INSTALLATION: Specify that, after dampers are installed, the contractor shall operate each damper through all positions to assure free operation.
    - .1.2 INSPECTION: Specify that, at final acceptance inspection, approximately 10 percent of all fire and smoke dampers, as randomly selected by the University Engineer, must be demonstrated by the contractor to be in proper position and in operational order. Failure of any one of the demonstrated dampers shall require the contractor to check and demonstrate all dampers.
    - .1.3 CERTIFICATION: Specify that the contractor must certify in writing that all fire and smoke dampers were checked by operation at installation and that all are in proper position and functional order.
- 23 34 00. HVAC FANS
  - .1 GENERAL REQUIREMENTS: Centrifugal fans are preferred for supply and return air requirements. Tubular centrifugal, axial and propeller fans may not be used unless written authorization is obtained from the University Engineer.
  - .2. SUPPLY AND RETURN AIR FANS:
    - .2.1 HIGH PRESSURE FANS: Fans selected for operations above 6-1/2 inches static pressure are subject to approval by the University Engineer.
  - .3 EXHAUST FANS:
    - .3.1 EXHAUST FOR HAZARDOUS AIRBORNE CONTAMINANTS: Exhaust fans handling dangerous or obnoxious agents of a contagious disease shall discharge vertically from an outlet and extend at least eight feet above the roof of the building at velocities in excess of 3,000 feet per minute. Extreme care must be

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

exercised to avoid locating exhaust fans and ducts close to: high roof lines, other systems, radioactive systems, operable windows, doors, or fresh air intakes.

.3.1.1 Finishes for Exhaust Systems: Consideration should be given to the use of special metal in preference to special paint when designing exhaust fan systems for use with dangerous, corrosive, or obnoxious fumes.

### 23 36 05. AIR TEMPERING SYSTEMS:

#### .1 GENERAL DESIGN CONSIDERATIONS:

- .1.1 Outside air, in lieu of machine cooling, shall be utilized on air conditioning systems serving spaces with cooling loads when outside temperatures of 56 degrees F or below are prevalent and when the cost for additional work and equipment involved can be justified.
- .1.2 Variable volume air distribution systems should be used to vary the air quantities with the loads rather than falsely loading the system with reheat or mixing at the terminal units. Space-air outlets should be aspirating types to prevent dumping of unmixed air into occupied spaces.
- .1.3 Interior spaces requiring cooling the year around should be handled independently from perimeter areas requiring heating during winter and cooling during summer. Interior areas should be supplied from a variable volume cooling system utilizing a controlled economizer cycle. The perimeter systems should utilize controlled economizer cycles when cooling is required and minimum ventilation rates when heating is required.
- .1.4 Heat recovery systems should be considered for use when shutdown of systems cannot be accomplished during hours when building is unoccupied. Each application should be examined independently to determine any special sources for obtaining a recovery of energy.
- .1.5 Local cooling for limited areas or rooms may be provided by window air conditioners with approval by the University Engineer. See Appendix R.

#### .2 EQUIPMENT:

- .2.1 General: Equipment shall be of adequate size to handle air quantities and static pressure in accordance with design. Air quantities and distribution pattern shall be shown on the pattern drawings. Provisions for controlling air flow to or from outlets shall be included in the specifications, as well as indicated on the drawings. Air velocities in branch runs shall be kept low enough to maintain acceptable noise levels at air grilles.
- .2.2 Fans and Air Handling Units:
  - .2.2.1 Fans: Specify each type of fan separately. All fans shall be statically and dynamically machine balanced and fan motors shall operate within nameplate values.
    - .2.2.1.1 Fan ratings shall be based upon test performance in strict accordance with the AMCA Standard 210-67 Test Code for air moving devices. Specify that each fan bear the seal authorized by AMCA indicating that ratings are certified and that fans not bearing this seal will not be accepted.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .2.2.1.2 Centrifugal fans with motors 5 hp or over shall have bearings of the split pillow block, double row roller or ball, grease-lubricated type, with pedestal-type supports. Bearing life per Anti-Friction Bearing Manufacturers Association rating procedures shall be 90 percent expectancy of reaching at least 87,360 hours under design conditions.
- .2.2.1.3 Space Planning: Fans, motors, and drives shall be located so that safe and easy access for periodic inspections and maintenance is possible.
- .2.3 Drives: The following guidelines must be considered in the selection of, and specifications for, belt drives:
  - .2.3.1 Single belt drives shall not be used on equipment with 1 hp motor and over.
  - .2.3.2 Drives shall always be installed with provisions for center distance adjustment. Motors shall be located on their respective motor bases allowing for 1/6 of the total motor base travel for installation of new belts with remaining 5/6 of the travel available for belt tightening.
  - .2.3.3 Arc of contact on the smaller sheave should not be less than 120 degrees.
  - .2.3.4 Ratios should not exceed 8 to 1.
  - .2.3.5 Belt speed should not exceed 5,000 feet per minute.
  - .2.3.6 A full and free circulation of air should be around the drive at all times.
  - .2.3.7 Drives operating in an explosive atmosphere should be well grounded and equipped with static-conducting belts.
  - .2.3.8 Variable drive pulleys used with 5 hp and larger motors are prohibited on final drive installations. Specify that original sheaves be changed when required to achieve proper rpm balancing.
  - 2.3.9 Power Factor Correction: Motors (drives) 50 hp and larger shall be provided with fused, switched, power factor correction capacitor sized to correct to 100 percent or greater. Units shall be connected between the contactor contacts and overload coils. Units shall meet all fire and environmental codes.
- .2.4 Ducts: Ducts shall not be run above electrical panelboards, switchboards, substations or within electric rooms except for the duct serving the electrical room.
- .2.5 FRESH AIR SUPPLY:
  - .2.5.1 Intakes: Fresh air intakes shall be located in a vertical plane a minimum of 8 feet above grade and should not be located in close proximity to loading docks, driveways, loading zones, or any other contaminant

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

source. Sufficient distance or a direction change of fresh air shall be provided between the outside air intake louver and the filters to eliminate snow and rain being carried to the air filters. Intake ducts ahead of filters must incorporate adequate and accessible drains. Duct must also be totally rust resistant.

.2.5.2 Masonry Structures: If masonry plenums or air shafts are used to handle air flow, they shall be coated with special materials or lined with sheet metal to make them air tight.

.2.6 Return Air: Include return air fans in ventilation systems. Provide controls to coordinate return air fans with supply fans and to use return air or outside air as needed for highest energy efficiency.

.2.6.1 Plenums: The use of return air plenums in lieu of ducted return air systems is prohibited.

### 23 40 00. HVAC AIR CLEANING DEVICES

.1 REQUIREMENT FOR FILTERS: All air supplied by a forced air type unit or system shall be filtered. Pre-filter in a single filter installation or a pre-filter intermediate filter combination shall be upstream from the coils. After-filter, where required, shall be on the discharge side of the fan and downstream from all coils. All HVAC equipment shall have new filters provided by the Contractor upon completion of construction and the Contractor shall provide new filters at the end of the 1 year warranty period.

.2 SPACE REQUIREMENTS: Adequate clearances must be allowed for cleaning or changing filters.

.3 EFFICIENCIES: Filter efficiency shall be specified and shall be in accordance with the following guide for unit efficiency.

Pre- Filter % Efficiency	Intermediate- Filter % Efficiency	After- Filter % Efficiency
17-25	None	60
17-25	60	80-95
17-25	60-90	95-99

.4 DRAFT GAUGES: See 23 05 19.2

.5 AIR FILTRATION FOR HOSPITALS: Air filtration shall comply with the Guidelines for Design and Construction of Hospitals and Health Care Facilities.

.6 PRE-FILTERS in a single filter installation shall be of the following types; filter size and thickness shall be specified.

.6.1 Throw-away type.

.6.2 Disposable media pad between permanent frames.

.6.3 Disposable media pad and frames.

.6.4 Disposable filtering media for roll-type filters. Roll-type filters shall not exceed 10 ft. in width for horizontal or vertical operation and shall be provided with dust covers and motor and drive covers. The filter media shall be provided with adequate support to keep it from being pulled out of place.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .7 INTERMEDIATE AND AFTER-FILTERS shall be of the following types:
  - .7.1 Dry-type throw away cartridges. Cartridge casings shall be fabricated from zinc-coated steel, with fully gasketed holding frames with compression fastening devices set in a zinc-coated sheet steel frame.
  - .7.2 Deep pockets of high performance filter media.
  - .7.3 Bag-type filter, fixed to a zinc-coated steel holding frame and equipped with wire supports to hold bags erect.
- .8 ELECTRO-STATIC FILTERS may be incorporated in a project only with approval of the University Engineer.

### **23 50 00. CENTRAL HEATING EQUIPMENT WITHIN BUILDINGS**

- .1 GENERAL PROVISIONS: Refer to paragraph 01 78 23 (01730). in Division 01; specifications shall include provisions for:
  - .1.1 TRAINING OF UNIVERSITY OPERATORS by specially qualified personnel furnished by the boiler manufacturer.
  - .1.2 OPERATING AND MAINTENANCE INSTRUCTIONS: Four sets of operating and maintenance instructions and wiring diagrams shall be submitted to the University Engineer.
  - .1.3 CAPACITY AND EFFICIENCY TESTS of each boiler, including the proper testing of other equipment in the boiler plant installation.
  - .1.4 TESTS: The specifications shall be written to require the contractor to prepare and perform all tests, to place the boiler in operation, and to demonstrate to designated University personnel that the safety valves and all other safety and control devices function properly.
- .2 COORDINATION WITH BUILDING DESIGN:
  - .2.1 TWO SEPARATE MEANS OF EGRESS shall be provided, consistent with requirements of current Ohio Building Code, in boiler plants housing large boilers.
  - .2.2 LOCATION AND ARRANGEMENTS of the combustion air openings shall be such that any piping or equipment in the boiler room will not be subject to freezing.
  - .2.4 ACCESS for cleaning, replacement of tubes or sections, and maintenance is mandatory. Show manufacturer-specified clearances on plan views and elevation views for tube-pull areas, flanges, unions, etc., as needed to remove equipment heads as required for service.
  - .2.5 SPRINKLER PIPING IN CEILING SPACE OF VESTIBULES and similar locations shall be protected from freezing.
  - .2.6 LEAK DETECTION requirements shall be discussed with the OSU Project Manager. Take into account such factors as upper floor mechanical rooms, coils



## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

that see freezing entering air conditions, and cost of damage to building and its contents. Alarms shall be connected into the Building's Automation System and annunciate at the BAS shop.

### **.3 FUEL HANDLING EQUIPMENT:**

.3.1 GENERAL: Fuel handling equipment and fuel burning equipment on boilers shall comply with FIA recommendations.

### **23 52 00. HEATING BOILERS:**

.1 PREFERRED BOILER PLANTS: Where their use is practical, hot water boilers are preferred over steam boilers.

.2 SEPARATE PLANTS: Many buildings will be heated with separate boiler plants. It is the intent of the University that these plants be fully automatic and equipped with the latest and best safety devices.

.3 SIZES: Plants shall be designed with boiler sizes so selected as to not require an attendant licensed operator.

.4 ELECTRIC BOILERS: The A/E must submit for review and approval by the University before applying any electric boiler. Electric boilers shall use the highest voltage available. Electrode boilers are favored over resistance-element type boilers. Adequate provisions shall be made for boiler capacity control.

.5 STEAM BOILERS: Steam boilers shall have blow down tanks located below the boiler water level in compliance with the State of Ohio rules for the construction and installation of steam boiler blow off systems.

.6 VIBRATION CONTROL: Boilers located on floors above grade shall be installed on pre-compressed fiberglass vibration pads.

.7 ALUMINUM HEAT EXCHANGERS: Use of boilers having aluminum heat exchangers requires approval by the University Engineer.

### **23 52 10. BOILER ACCESSORIES:**

.1 THE WATER COLUMN on steam boilers shall comply with the Ohio Boiler Code. Float controls are desired.

.2 CONTROLS: On multiple boiler plants, the controls shall be of the modulating selector type so that individual boilers can be made to lead or lag. These controls shall be located in view of the boilers themselves so that personnel can see the boilers as controls are being adjusted.

.2.1 Float chambers of level control devices shall have gate valve drains with pipes extended to discharge over a floor drain.

.2.2 Pressure Type Relay: Steam boiler plants having more than one boiler shall have a pressure type relay and non-return valve on each boiler to prevent steam pressure in lag boilers from dropping below header pressure. (The purpose of this control is to prevent header steam from condensing in the boiler and raising the water level above the high level point in the header).

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .2.3 Aquastat Relay: On steam and hot water boilers, an aquastat relay shall be installed on each boiler to prevent the burner from reaching high fire rating before the water temperature in the boiler rises to within a few degrees of the normal operating temperature.
- .2.4 Safety Valves: On both hot water and steam boilers, relief valves shall be installed and so vented that they may be blown down without danger to personnel. Design will require adequately sized vent lines with appropriate drains to prevent steam and hot water from blowing back into the boiler room or other areas where they can endanger personnel.
- .2.5 Vacuum Breakers: Each steam boiler shall have a vacuum breaker provided on a pipe connected to the top of the water column or float control for vacuum release.
- .2.6 Cut-offs: Boilers shall have a low water cut-off on the burner.
- .3 GAUGE GLASSES shall be automatic ball shut-off type.

### **23 53 00. HEATING BOILER FEEDWATER EQUIPMENT:**

- .1 WATER SOFTENER: Each boiler room shall be provided with a water softener for boiler feedwater makeup.
- .2 THERMAL SHOCK PREVENTION: Each steam boiler plant shall have a factory assembled de-aerating feedwater heater with automatic controls. The heater shall be located at an elevation to provide net positive suction head for the boiler feedwater pumps. Hot water boilers shall have system piping and cold water makeup arranged to prevent cold water from entering a hot boiler.
- .3 CHEMICAL TREATMENT: Boilers shall be provided with individual means for feeding chemicals into the boilers. Steam boilers having an output of 3,000,000 Btu or more and having at least 75 percent feedwater makeup requirement shall be provided with an automatic surface blow off arrangement. The device shall maintain a constant conductivity concentration by means of a boiler water probe and controller. Boilers having a high makeup requirement shall be provided with special chemical feedpumps for continuously feeding chemicals into the boiler.
- .4 BACK FLOW PREVENTERS: Domestic "makeup" waterlines to boilers shall be provided with backflow preventers.

### **23 60 00. CENTRAL COOLING EQUIPMENT**

#### **23 60 05. COILS AND PIPING SYSTEMS:**

- .1 COILS: All coils shall be ARI certified. Direct expansion coils may be used on small systems and shall be piped and installed in accordance with factory recommendations, if the installation can be considered normal or average by the manufacturer. Additional design precautions shall be taken, or a field refinement procedure shall be included in the specifications, on those installations not covered by the manufacturer's guide.
  - .1.1 Water coils shall have copper tubes (0.035" thickness) with aluminum fins, permanently bonded. Steam coils that could see superheated steam shall have 316 stainless steel tubes. Water cooling coils shall be designed for full counter-flow of water and air with water inlet at the bottom of the supply header and outlet at the top of the return header.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .1.2 Water Coils versus Steam Coils: Hot water coils are preferred over steam. Use of steam coils requires prior approval by the University Engineer.
  - .1.2.1 For VAV (variable air volume) HVAC systems, include a preheat coil of sufficient size to preheat the code-required minimum ventilation air up to 55 Deg F leaving air temperature. This will help to prevent nuisance low-temperature shutdowns, and will help to avoid negative pressurization of the building, during the heating season.
  - .1.2.2 For any hot water preheat coil provide either:
    - .1.2.2.1 integral face-&-bypass dampers and a control valve piped normally open to the coil; above 40 F position dampers full open to coil and modulate control valve; below 40 F position valve wide open to coil and modulate dampers, or
    - .1.2.2.2 a coil recirculation pump for continuous flow through the coil and a control valve piped normally open to the coil. The control valve shall modulate to maintain preheat discharge air temperature.
    - .1.2.2.3 The heating control valve shall remain in control when the fan is OFF, except upon alarm of the low-temperature detection thermostat.
  - .1.2.3 Steam coils, if used, shall be positive drain type with vacuum breakers, air vents, and double parallel condensate traps to reduce the possibility of freeze-up. The steam coils shall be installed with suitable pitch such that condensate shall naturally drain from the coil. Steam coils shall have integral face & bypass dampers. Provide adequate differential pressure for steam traps. Do not lift condensate if modulating steam valves are used.
- .1.3 Design Details:
  - .1.3.1 Condensate Removal: Whenever cooling coils are stacked one above the other in a plenum, drip troughs shall be installed on the downstream side of the top coil(s) to eliminate drip into the air stream of the bottom coil. Pay special attention to pitch of cooling coil housing, exterior piping, and traps to ensure adequate removal of condensate from the plenum.
  - .1.3.2 Access: Provide access per manufacturer's recommendations. Access on inlet, outlet, and both ends of coils is desired, if possible, for maintenance and/or replacement purposes. Provide coil pull space on the piping connection side. **[Student Life – access on both ends is required to permit repair of tube bends without removing coil.]**
  - .1.3.3 Freeze-up Protection: Specify that the volume of heating medium being supplied to a coil facing outside air shall not be modulated. Provide manual freeze-up protection, applied to the downstream side of the coil.
- .2 PIPING: Piping for hot and chilled water systems shall include isolation valves, drain valves, air vent facilities, and pipe unions at each coil, as well as a lockshield balancing valve or balancing cock for those systems having more than one coil being served. Air vents (automatic, or manual, as appropriate) with a line extended to an adjacent floor drain shall be specified for installation wherever air is likely to be trapped. A strainer with isolation valves on the suction side of a pump and a pressure relief valve are required on

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

all systems. Back-flow preventers shall be provided to prevent contamination of potable water systems.

- .2.1 Refer to Appendix for Technical Provisions for Corrosion-Scale Inhibitors, Microbiocides and Water Analysis Services for Cooling Towers.
- .2.2 Refrigerant Piping: Accessory equipment in a refrigerant circuit shall include:
  - .2.2.1 A dryer of adequate size.
  - .2.2.2 Sight glass-moisture indicator, installed in the liquid line at a convenient and accessible location.
  - .2.2.3 Liquid solenoid valve located near the expansion valve on systems using coil pump-down.
  - .2.2.4 Service hand valves shall be considered a convenience on small refrigerant systems and a necessity on extensive or large systems. They shall be located for component isolation purposes during normal maintenance.
  - .2.2.5 Liquid charging port and service valve installed in the liquid line for large systems.

### **23 61 05. COMPRESSORS**

- .1 COMPRESSORS OF 60 TO 100 TON CAPACITY: Screw or scroll type, equipped with full running protection as described for larger compressors, suction and discharge oil pressure gauges, crankcase heater(s) oil reservoir sight glass, replaceable refrigerant filter-dryers and 5-year warranties. Incorporated features shall include the following:
  - .1.1 Deleted.
  - .1.2 Positive unloaded start.
  - .1.3 An adequate discharge muffler.
  - .1.4 Internal vibration isolation to provide minimum vibration transmission.
  - .1.5 Closed transition starting switchgear, determined by the electrical specifications for the particular sizes of motors.
  - .1.6 Air cooled units shall be furnished with a receiver on the condenser and provisions for pumping the full refrigerant charge into the receiver.
  - .1.7 Power factor correction as described for large compressors.
  - .1.8 Provide low ambient accessory as required for the particular application.
- .2 COMPRESSORS UNDER 60 BUT OVER 15 TON CAPACITIES shall be scroll type. Incorporated features shall be as specified in paragraph 23 61 05.1 plus inherent thermal overload protection for motors. Provide low ambient accessory as required for the particular application
- .3 COMPRESSORS BELOW 15 TONS OF CAPACITY SHALL be scroll. Unloaded start features are not required, but should be considered. Units shall have inherent thermal

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

overload protection for motors. Provide low ambient accessory as required for the particular application.

.4 COMPRESSOR PRESSURE RELIEF DISCHARGE PIPING -See 23 20 03.

23 63 05. CONDENSING UNITS AND CONDENSERS:

.1 All condensing units under 100 tons shall come factory pre-charged with NON-CFC refrigerants and compressor manufacturers recommended lubricating oil. The unit shall be clearly marked as to the refrigerant and oil that it contains.

.2 SPECIFIC DESIGN REQUIREMENTS:

.2.1 CONDENSER CONSTRUCTION: Blow-through evaporative condensers are preferred to draw-through units. Where required for all season operations, air cooled systems shall be designed for condenser location within equipment rooms with discharge air to the outside. Where this is not possible, the condensers must be exterior mounted, the system shall be provided with adequate winter protection to prevent short cycling of the system. Winter protection shall be in accordance with the manufacturer's recommendations and so warranted by the manufacturer.

.2.1.1 Air cooled condensers shall be selected in accordance with ASHRAE Standard 20-70 or ARI Standard 460-70 using 115 degrees F condensing temperature and 95 degrees dry bulb entering air temperature.

.2.1.2 Water-cooled condensers utilizing city water are prohibited. Exception: evaporative condensers.

.2.1.3 Modulating dampers used for controlling air quantities through towers or condensers shall have non-ferrous blades, linkages, and bearings. The operator motors and linkages shall be located outside the tower for convenient maintenance and operation.

.3 ARRANGEMENT OF EQUIPMENT:

.3.1 Condensers shall be located so that tubes can be rodded without hindrance from walls, piping, or equipment.

.3.2 Evaporative condensers shall be located near their compressors to reduce refrigerant piping to a minimum.

.4 CONDENSER PIPING: Piping of condensers shall have proper and adequate fittings and supports to facilitate removal of water box ends for maintenance. One set of flange fittings shall be located adjacent to the water box and a second set of flange fittings located away from the water box at such a distance that would permit the removal of the header and to provide maintenance space. This same provision for removal of headers in piping shall be made in the chilled water circuits at the chiller unit. Provisions shall be made for TDS-controlled blowdown per Appendix. Dry sumps shall be utilized with interior storage when winter operation is required.

.4.1 Water treatment control of pH and solids shall be provided. Backflow prevention or an air gap shall be provided to prevent contamination of all potable water systems. Refer to Appendix for Condenser, Water Treatment System Sample Specification.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .4.2 Condenser water lines and city water make-up lines exposed to the weather shall have drain facilities properly located to allow drain down of the system to prevent freeze-up during the winter.
- .4.3 Check valves shall be installed on condenser water pump discharge lines where a reverse flow could occur in event of pump shut down.
- .4.4 A basket type strainer shall be installed ahead of the condenser water pump on all systems. Strainer shall be valved so that minimum amount of water will be lost when strainer is removed for cleaning. The pressure gauges on any condenser water strainer or condenser water pump shall be compound-range gauges, such that if the strainer becomes plugged, the gauge will read below zero (0) without damage to the gauge.
- .4.5 Refrigerant piping to and from an air-cooled condenser shall be installed in accordance with the manufacturer's recommendations (re: pipe size, traps fittings, and receiver size).
  - .4.5.1 Installation of Refrigerant Piping: Specify that lines be fitted, installed, and pressurized with dry nitrogen before being brazed. Use 6 percent or higher silver alloy with a 1000 degrees F solidus minimum. Specify that lines be blown with dry nitrogen to eliminate brazing debris before starting evacuation and charging procedures.
  - .4.5.2 Elbows and fittings for refrigerant lines shall be long-radius to minimize capacity loss.

### **23 64 05. CHILLERS:**

- .1 CHILLERS OF OVER 100 TON CAPACITY: Units will be centrifugal or screw type which utilize NON-CFC refrigerants with safety classification A-1 or B-1 (as defined per ASHRAE Standard 34-2001 -- Designation and Safety Classification of Refrigerants) such as R-134a or R-123. The use of HCFC-22 is not permitted for use on campus. The primary considerations are high efficiency at part load, high efficiency at full load, low acoustic noise, ease of service, high reliability of operation, low operating costs, low service costs, fast response from local service representatives, and ease of data transfer using BACnet communications to the building automation system from chiller controller. Also specify:
  - .1.1 Motors: Dual winding, star-delta design, with matching two-step, closed transition, time-delay starting switchgear is preferred. An auxiliary timer in the starting circuit is required. Specify that timer be set to limit starts to a minimum of 60-minutes apart, or greater as recommended by the manufacturer.
    - .1.1.1 Alternate Starting Arrangements: An auto-transformer with reduced voltage start or solid state starter are acceptable alternates.
    - .1.1.2 Thermal Protection: All motors shall have heat sensors in the windings for thermal protection.
    - .1.1.3 Consider variable frequency control of chiller drive motor; justify with Life Cycle Cost Analysis.
  - .1.2 Power Factor Correction: The equipment manufacturer shall provide fused, switched, power factor correction capacitors to correct to 100 percent or greater.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

It is preferred that the units be connected after the contractor, before the overloads. Units shall meet all fire and environmental codes.

- .1.3 Full-running Protection: Specify that compressors be equipped with high and low pressure safety cut out, external overload protection, and low oil pressure safety cutout. Safeties shall be manual reset type initiating an electrical lockout of the starting circuit when tripped, with an indication of which safety device has tripped.
- .1.4 Gauges: See 23 05 19.2.
- .1.5 Forced feed lubrication with filter, cooler and visual inspection port in the oil reservoir shall be provided.
- .1.6 Capacity Control: A capacity control will be located in the machine control cabinet with an adjustable range of 20 to 100 percent. This will be a pneumatic-electric or a microprocessor based device suitable for remote reset.
- .1.7 Heaters: Compressors shall be equipped with crankcase heaters wired on a separate electrical circuit. Units using low-pressure refrigerants shall be furnished with purge units to eliminate the non-condensable gases. Units shall be furnished with a pump-out unit and receiver large enough to hold the full refrigerant charge.
- .1.8 Air-cooled units shall be furnished with a receiver on the condenser and provisions for pumping the full refrigerant charge into the receiver.
- .1.9 Bidding Requirements: See Division Facility Services-6 for Base Bid requirements for CHILLERS over 100 ton capacity.
- .1.10 Evaporator and condenser connections shall be specified to include marine boxes which will permit ease of service to tubes.
- .1.11 Oil filtration system shall be specified to include isolation valves, to isolate the filter from the machine and avoiding removing the refrigerant charge when servicing the oil filter.
- .1.12 Refrigerant circuit shall be specified to include refrigerant isolation valves, and sufficient volume in both evaporator and condenser to allow all of the refrigerant to be moved into one section of the circuit while servicing the other section, to avoid removing the refrigerant from the machine.
- .1.13 Extended Warranty: Review including a 5-year parts and labor chiller warranty and a 5-year refrigerant warranty with OSU Project Manager.

### **23 65 00. COOLING TOWERS:**

- .1 GENERAL DESIGN REQUIREMENTS: Cooling towers shall be of the induced draft design with propeller type fan. Fan drive shall be right angle gear type with electric motor mounted outside the air stream.
  - .1.1 Free-standing towers shall be provided with appropriate factory made service platforms, ladders and a safety railing to provide adequate access for servicing the equipment inside and on top of the tower.
  - .1.2 Cooling towers shall be sized based on 78 degree F wet bulb outside air temperature, 95 degree F entering and 85 degree F leaving water temperature. Cooling tower capacity requirements shall be checked by the A/E throughout the

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

full operating range of the chiller and outside air ambient conditions to ensure adequate tower capacity.

- .1.3 Fan motors shall be inverter-rated, to permit warranted-use of the motors when controlled by variable frequency drives.
- .1.4 The use of variable frequency drives for tower fans is strongly encouraged in order to provide the lowest suitable condenser water supply temperature to the chillers, such that the chillers can operate more efficiently at the lowest lift.
- .1.5 Provide tower bypass control valves in order to allow friendly start-up to chillers and avoid nuisance shutdowns of chillers with too-cold tower water. It is encouraged to apply a two-way tower-bypass valve for modulating control with a line-size valve to the tower for positive shut off of flow to the tower. Avoid using three-way valves. Consider having the chiller directly controlling the bypass valve in lieu of the Building Automation System.
- .1.6 The tower condenser hot water distribution pans and cold water sumps shall be stainless steel
- .1.6 For towers with indoor sumps, provide a 1"-size drain-equalizer at the indoor sump, interconnected between tower supply and tower return lines, such that both lines will automatically drain to the sump. The 1" drain-equalizer shall have zero (0) valves and shall be continually open to both lines.

### **23 80 10. LIQUID HEAT TRANSFER:**

- .1. HOT WATER HEATING PIPING AND INSULATION: Refer to Sections 23 07 19, 23 20, and 23 20 09.
- .2. STEAM HEATING PIPING AND INSULATION: Refer to Sections 23 07 19, 23 20 05, and 23 20 09.
- .3. HEAT EXCHANGER PIPING AND INSULATION: Refer to Sections 23 07 19, 23 20 05, and 23 20 09.

### **23 80 15. DESUPERHEATER (DSH) STATION:**

- .1 Desuperheat all superheated steam to within 20 F of saturation downstream of the main high pressure building pressure reducing station. Submit details for construction and installation during preliminary design for review and approval.
- .2 Review with OSU Project Manager whether: 1) the DSH should be designed for N+1 (100% backup), or 2) all equipment downstream should be designed for superheated temperature, or 3) an automatic shutdown of the steam system upon failure of the DSH is desired. [One of these methods shall be provided.] Automatic shutdown valve shall be slow-closing (2 minutes, adjustable, from fully-open to fully-closed).
- 3. Each DSH shall have at least a 100:1 turndown ratio and be sized for the peak design steam load. DSH shall be Copas Vulcan VO II (variable orifice) or Schutte & Koerting Fig. 6910 (absorption). Other types of DSH (e.g., steam atomizing) are prohibited. Provide DSH control system per Appendix A.
- 4. Steam condensate (not domestic water) shall be used for DSH cooling. Consider using coalescing dirt separator. If DSH is designed for N+1, the condensate cooling injection system shall also be designed for N+1.



## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

### 23 80 17. DESIGN AND INSTALLATION OF STEAM PRESSURE REDUCING STATIONS:

- .1 SOUND ATTENUATION: Provide either sound attenuating valve trim or a downstream in line silencer or both to maintain noise levels below 85 dB. Attenuator outer body and inner wall shall be of steel construction with pressure and temperature rating as required by the safety relief valve set point and stream conditions. Acoustical insulation shall be fiberglass for service below 300 degrees F and fiberglass with steel casing for service above 300 degrees F.
- .2 Not used
- .3 MAIN HIGH PRESSURE BUILDING STATIONS: Steam stations processing campus high pressure steam at 200 psig at 600 degrees F to produce building utilities such as heating hot water, domestic hot water and reduced pressure process steam shall be located immediately adjacent to an exterior wall. The Control Valves shall be selected to satisfy winter and summer steam usage, which in most cases has a turndown of 50:1. Routing campus high pressure lines through interior building spaces is prohibited except in the case where the steam line is completely enclosed in a utility tunnel physically segregated from interior building space. The space shall be adequately ventilated /cooled to achieve an overall temperature not to exceed 95 degrees F at a distance of 4 feet from the station. Label all piping that is anticipated to carry superheated steam with the appropriate abbreviation listed in the Facility Services section and an additional 'S' plus steam pressure in parentheses. For example medium pressure superheated steam: MPSS (70 psig). High pressure stations, requiring close reduced pressure control and reliable operation, shall be designed to include:
  - .3.1 Valves shall be cast carbon steel body, Class 300 rating and flanges or threaded ends, Stellite-faced stainless steel plug, cage, and seat ring, normally closed single port, cage guided, bonnet extension, with graphite packing and Belleville style washers.
    - .3.1.1 Diaphragm shall be molded type suitable for 300 degrees F operating temperature with a fabric insert, iron, steel, or aluminum diaphragm plate, silicone manganese-steel actuator spring, and stainless steel travel indicator scale.
    - .3.1.2 Pressure Controller: Specify that each valve be furnished with a proportional and reset action pressure controller with overload protection on the bourdon tube. For sensing line to bourdon tube, provide minimum 6-inch length of tubing for temperature reduction, steam syphon ("pigtail"), and three-valve manifold (all 316 stainless steel). Provide pneumatic pilot positioner. Provide supply and output pressure gauges at controller and valve positioner. See 23 05 19.2.
      - .3.1.2.1 A 1/4 inch filter regulator shall be installed in the air line ahead of each controller.
      - .3.1.2.2 The sensing line connecting the pressure controller to the steam pipe shall be #316 stainless steel pipe, minimum 3/8" NPT size, or larger as specified by the controller manufacturer. The sensor line shall be sloped down and away from the controller to the steam main.
      - .3.1.2.3 Valve manufacturers: Fisher, Copes Vulcan, Spirax-Sarco, or Leslie.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .3.2 The A/E shall provide a detailed steam system piping diagram on the Drawings to clarify the design intent indicated above, showing for example, steam pressures and temperatures, valve Cv ratings, relief valve settings, pressure gauges, and thermometers, etc.

*[Commentary: The steam system piping diagram will enhance the visual aid for the Operations staff for determining the status of the steam delivery system.]*

- .4 MEDIUM PRESSURE (LESS THAN 150 PSIG) HIGH VOLUME STATIONS: Medium pressure stations that can see superheated steam shall be same as for high pressure building stations. Medium pressure stations that can only see saturated steam and that require close reduced-pressure control shall be designed to include:

- .4.1 Valves shall be Class 300 cast steel body, Class 300 flanges or threaded ends, with Stellite-faced stainless steel trim, normally closed single port, cage guided, with PTFE packing.

- .4.1.1 Diaphragm, pressure controller, and filter regulator shall be the same as required for main building station.

- .4.1.2 The Control Valves shall be selected to satisfy winter and summer steam usage, which in most cases has a turndown of 50:1.

- .5 SMALL VOLUME STATIONS: Stations with small loads and that do not require close reduced-pressure control, shall be designed to include:

- .5.1 Air loaded (no pilot) reducing valve with no stuffing box.

- .5.2 High pressure and superheated steam valves shall have Class 300 screwed or flanged cast steel bodies, single port with top and bottom guided stainless steel valve plug, replaceable screwed-in Stellite-faced stainless steel seat, stainless steel main spring, and double stainless steel diaphragm. Medium pressure valves that can see only saturated steam shall be same except Class 150 cast steel body.

- .6 OTHER CONDITIONS: The A/E may consider using valve materials and pressure/temperature ratings different than described above if the building steam system is a lower temperature or pressure application. Where a desuperheater is used, the A/E shall consider the consequences of a desuperheater failure on the equipment installed downstream. The design assumptions for these conditions shall be documented in the Basis of Design and submitted to the University Engineer for approval.

*[Commentary: The A/E is encouraged to consider using valve materials and pressure/temperature ratings that meet the needs of the application without incurring unnecessary expense for the University. Some examples of such applications would be standalone boilers or systems using only desuperheated steam.]*

- .7 INSTALLATION DETAILS: Specify that:

- .7.1 Valves with pneumatic controls shall be provided clean, dry air at up to 80 psig, as required.

- .7.2 Steam gauges: See 23 05 19.2.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

- .7.3 Safety valve and safety valve vent shall be provided. Safety valves shall discharge to the outside. The pressure drop in the safety valve discharge piping shall be minimal so that it does not impede the safety valve operation. Where steam passes through regulators to a lower class of piping, safety valves shall be installed with enough capacity to prevent over-stressing the piping in the event of regulator failure.
  - .7.4 A drip-leg, full pipe size, and a trap be provided just ahead of each regulator to remove the moisture from the steam before it enters the regulator.
  - .7.5 A minimum of two regulators shall be provided on pressure reducing stations, both sized for full flow capacity with one being a standby. Regulators shall be installed with valves and unions or flanges so that any regulator can be removed without disturbing the others. Strainers (100 mesh) with blowdown valves shall be installed ahead of regulators. Where two valves are necessary to meet the summer-winter turndown (e.g. 1/3 – 2/3, or 1/4 -- 3/4), the standby valve shall be sized for the larger of the two valves. In lieu of a standby regulator, provide a full-flow globe valve bypass.
  - .7.6 Pressure reducing stations shall be of such design that regulators can be easily removed without straining the pipe.
  - .7.7 Gauges on steam lines should be compound-range gauges, such that gauges will not be damaged if steam systems draw a vacuum when shut-down.
  - .7.8 Provide removable/reusable insulation jackets on all devices, to reduce heat gain to the space, and allow for convenient service. Fiberglass insulation shall not be used on piping systems above 300 degrees F.
  - .8 ZERO ENERGY POTENTIAL: Double block and bleed techniques, as recommended by OSHA, shall be used to achieve ZEP (Zero Energy Potential) on all systems of 50 psig or higher.
- 23 82 10. COILS, RADIATORS, AND FAN COIL UNITS:
- .1 USAGE:
    - .1.1 Forced Air Type Units: An adequate supply of heat shall be provided at building entrances and in air locks. Cabinet unit heater with thermostat control shall be used. Units shall be equipped with filters to minimize dirt collection on coils.
    - .1.2 Convectors shall be used where architectural features cause an increase in heating requirements. When used, convectors shall have ratings based upon test procedures as set up by the Hydronics Institute, Institute of Boiler and Radiator Manufacturers (I=B=R).
    - .1.3 Through-wall type heating/cooling units shall not be provided with any liquid service to avoid winter freeze-up problems.
    - .1.4 Energy Conservation: Fan coil units and radiation will be required in specific areas to facilitate shutdown of major fan units after hours to save energy. Where necessary, the controls on these units shall be coordinated with the controls on the air handling units.
    - .1.5 Coils: All coils shall have a tube wall thickness of 0.035 inches.

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

---

.2

### DETAILS:

.2.1 Convector shall be wall hung type with sloping top and knob dampers. Elements shall be tested at 150 psi.

.2.1.1 Fins shall be non-ferrous, spaced not closer than 72 fins per foot.

.2.1.2 Tubes shall be copper.

.2.1.3 Cabinet shall be sheet metal, no less than sixteen gauge on fronts and tops, and eighteen gauge on backs.

END OF DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

## **DIVISION 26 – ELECTRICAL**

2006 Edition, Published January 1, 2006; Division Revision Date: February 7, 2017

### **26 00 00. ELECTRICAL**

#### **26 00 03. GENERAL PROVISION**

- .1 QUALIFICATIONS OF CABLE SPLICERS: Refer to Division 33.
- .2 INFORMATION FOR DESIGN OF SYSTEM: During the initial planning conference, consult the University and Facilities Design and Construction, regarding the choice of primary service voltage to be used, its location, and the capacity available. Refer to Division 33 00 03.3.1 for requirements that the Architect/Engineer's (A/E) Electrical Consultant shall follow.
  - .2.1 EQUIPMENT AND INSTALLATION GUIDELINES:
    - .2.1.1 an important aspect of Power System Design and Installation involves consideration of service reliability of the proposed system and loads that are to be supplied. System Installation inspection and Service reliability will be performed by the Contractor in the presence of the University Representative(s), Facilities Operations and Development, Electrical Utilities Shop when and if the Systems are to be connected to University Electrical Power Systems. The System shall not be energized if these requirements are not met or it fails Final Inspection.
    - .2.1.2 Contractor(s) and A/E's electrical consultant(s) are responsible for addressing all the Design review comments to the satisfaction of the university in order to assure the continued reliability of the University Power Distribution System.
  - .2.2 SAFETY
    - .2.2.1 the incorrect application of Electricity and unsafe installation can cause both minor and serious accidents. The Designer must remain vigilant to Electrical hazards and take appropriate steps in meeting all safety rules and regulations in Electrical Power and Installation Distribution Design. It is important that the Design meet requirements of the following codes and regulations; NEC, NFPA, OSHA, and National Electrical Safety Code. It is also important that all the Equipment, Devices and Installations supplied and installed in all University's Facilities meet high level of Safety Requirements, and the OSU Building Design Standards. It shall also be known that the equipment, devices, and installation that fail to meet these requirements will not be accepted.
- .3 OVER CURRENT PROTECTION COORDINATION: For any building with an electrical service larger than 1,200 amperes, an analysis of the coordination of over current protection shall be shown on the drawings.
  - .3.1 the coordination study shall show the system by elementary diagram and indicate Arc Flash Coordination Study, Load Flow the available fault current at critical points in the distribution system and the selection of over current devices for time and interrupting capacity coordination. This study shall be part of design services in addition to the ones supplied by the electrical contractor.
  - .3.2 a copy of the final studies shall be approved by the A/E and submitted to the University Engineer with two copies of the one line diagrams in a standard paper copies and in electronic form.

**Commentary:** *one line diagrams shall be full size drawings*

## DIVISION 26 – ELECTRICAL

---

- .4 COORDINATION OF HARDWARE: All electric panel doors shall be equipped with BEST Access Systems cylinders with removable 7-pin cores. Refer to Division 08 for further details.
- .5 Equipment belonging to other University Departments shall not be installed in or stored in Facilities Operations and Development mechanical or electrical rooms, unless permission is given by Facilities Operations and Development in writing.
- .6 Building electrical power shall be from the OSU power system, when in the vicinity and available.
- .7 PROHIBITED MATERIALS AND CONSTRUCTION PRACTICES:
  - .7.1 Door Closers: Refer to paragraph 08 70 20.5 regarding the prohibition against door closers with integral smoke detectors.
  - .7.2 Extra-flexible non-labeled conduit:
  - .7.3 Plastic conduit for interior electrical use, except that PVC conduit may be used for power circuits below basement concrete floors and for ground wires in any location. The transition from PVC to steel shall be made below the floor and shall be galvanized rigid steel conduit.
  - .7.4 Steel conduit shall not be used outside unless in concrete. Use aluminum conduit outside and wet locations above grade.
  - .7.5 Aluminum wiring shall not be used.
    - .7.5.1 Use of aluminum plated bus and aluminum wound transformers is prohibited in all OSU projects.
  - .7.6 Use of Incompatible Materials: Aluminum fittings and boxes shall not be used with steel conduit. All materials in a raceway system shall be compatible.
  - .7.7 Power actuated anchors or plug anchorage using wood, lead, or plastic.
  - .7.8 Multi-use Suspension Systems: Piggyback suspension systems for conduits, fixtures, etc. are prohibited. All suspensions must be hung independently from structure, or, in limited cases, from trapeze suspension systems.
  - .7.9 Use of wire ties to support conduit.

Exception: Flexible conduit for fixture whips may be supported with UV stable cable ties,
  - .7.10 Use of wood strips and wood screws to support lighting fixtures.
  - .7.11 Use of Class J fuses unless permitted otherwise in the Ohio State University Building Design Standards.
  - .7.12 Direct burial electrical cable at any voltage.
  - .7.13 Electrical ducts crossing above gas piping.
  - .7.14 Ducts within 10 feet of a buried steam line in any direction. If it becomes necessary to cross a steam line, acceptable insulation of the crossing must be approved by the Utilities High Voltage Services, Facilities Operations and Development.
  - .7.15 Hard insulated wire connectors, which have Bakelite or Ceramic insulation, are prohibited.

## DIVISION 26 – ELECTRICAL

---

- .7.16 Dimmable lighting unless permission is obtained in writing from the University Engineer. See 26 58 00.3.
- .7.17 Armored cable (BX, AC, etc.)  
Exception: MC Cable (Metallic cable with green ground wire) may be used where permitted in the OSU Building Design Standards
- .7.18 Nonmetallic sheathed cable.
- .7.19 Flat conductor cable type FCC, under carpet, etc.
- .7.20 Fluorescent fixtures using other than 4-foot tubes are discouraged. Where 2' x 2' fixtures are needed, use 2' long fluorescent tubes. Fluorescent U tubes are prohibited.
- .7.21 Die cast setscrew and die cast compression type fittings.
- .7.22 Locating the following equipment less than three feet from a wall: electrical equipment that permits or requires rear cooling, rear access for maintenance or cleaning, or rear connection.
- .7.23 Bottom fed switches, breakers or fuses.
- .7.24 Switches in which the blades pivot on the top.
- .7.25 Switches, breakers, etc. that require greater than 75 pounds of force on the operating handle.
- .7.26 Use of compact fluorescent lamps and/or T5 fluorescent lamps and fixtures as the main source of illumination in any area are prohibited unless approved by the University Engineer. Otherwise the use of compact fluorescent lamps or T5 fluorescent lamps shall be limited to accent lighting.  
  
**Commentary:** *The definition of "accent" is a wall or artwork not "a task or an egress path". T5 Fluorescent lamps have no standard sockets; hence they cannot be purchased from the open market. It is not cost effective for maintenance.*
- .7.27 Use of cable tray with primary conductors.
- .7.28 Time clock controls used on exterior or security lighting.
- .7.29 Use of busway other than as permitted in Section 26 05 35.11.
- .7.30 Use of bus way for panel risers.
- .7.31 Tapping existing switchgear, switchboards, panelboards, and motor control centers to provide power for new feeders or equipment is prohibited in all University facilities.
- .7.32 Troffers: Use of radiant ceiling panels.
- .7.33 Lamps not manufactured by GE, Phillips, and Sylvania.
- .7.34 Lamps provided by only one Manufacturer.
- .7.35 Fixtures that require proprietary lamps.
- .7.36 General Duty Safety Switches
- .7.37 Custom Built Lighting Fixtures
- .7.38 Recessed step lighting fixtures

## DIVISION 26 – ELECTRICAL

---

- .7.39 Exterior wall recessed mounted lighting fixtures
- .7.40 Flush mounted in-ground fixtures
- .7.41 Exposed wiring of any type in mechanical and/or electrical rooms
- .7.42 Top entry in any exterior electrical equipment.

### .8 SPECIAL REQUIREMENTS FOR MANHOLES OR VAULTS

- .8.1 Manholes shall not be installed inside buildings.
- .8.2 If there are existing manholes (MH) or vaults inside buildings undergoing major renovation that can not be moved or relocated, then provision must be made for access by *a live truck, known as the High Voltage Truck*, for emergency pair, maintenance, and cable termination or replacement.

### 26 05 05. ELECTRICAL MATERIALS AND METHODS:

- .1 UL LISTED EQUIPMENT AND MATERIALS: Specify only Underwriter's Laboratories listed equipment, assemblies, and materials when such items are available. The equipment and materials shall be installed in accordance with its listing.

### 26 05 15. WIRE AND CABLE

- .1 MATERIAL: Copper conductors of 98 percent conductivity shall be used unless use is restricted by Government Agencies.

### .2 SECONDARY CONDUCTORS:

#### .2.1 COLOR CODING

Color-coding for 480/277V and 208Y/120V shall be as follows:

Phase	Voltage - 208Y/120	Voltage - 480Y/277
Neutral	White/Gray	White or Gray (each with identifiable colored stripe)
A	Black	Yellow
B	Red	Orange
C	Blue	Brown
Equipment	Green	Green w/ Yellow stripe

Ground

- .2.2 Solid and Stranded Wire: No. 12 AWG and smaller may be solid. No. 10 and larger shall be stranded.
- .2.3 Minimum size for lighting and power branch circuits: No. 12 AWG.
  - .2.3.1 Use No. 14 AWG stranded for control wiring between control panels and motor starters.
- .2.4 Field wired incandescent fixtures shall be wired with Type SF 150-degrees C 300-volt wire.



## DIVISION 26 – ELECTRICAL

---

- .2.5 Field installed cords to portable equipment shall be type ST or G and Field installed cords for normal Equipment shall be type SRDT containing identified equipment.
- .2.6 Circuit wiring through ballast channels of fluorescent fixtures shall be 600-volt 90-degrees C insulation. Fixture must be approved for through wiring, if thus used.
- .2.7 General use insulation: NEC, 600-volt type THHN/THWN or XHHW.
- .2.8 Connections in No. 10 and smaller wire shall be made with threaded-on plastic or nylon insulated wire nuts. Crimp connectors, except butt connectors, are prohibited. Joints in No. 8 and larger conductors shall be made with pressure type mechanical or split bolt connectors insulated with plastic electrical tape.
- 2.9 MC cable may not be used in the following applications unless approved by the University Engineer:
  - Exposed conditions, in mechanical and electrical rooms, kitchens, science laboratories, utility spaces or medical facilities. MC shall also not be run exposed below eight feet above finish floor or as direct runs back to the panelboards.
  - Exception: MC Cable may be used as fixture whips for lighting fixtures provided MC cable longer than 6' shall be properly supported.
  - Exception: MC cable may be used in existing walls
- .2.10 MC Cable may be used for branch circuiting in offices, pool classrooms, and corridors of office and classroom buildings provided it is supported properly and run taut.

### 26 05 17. WIRING DEVICES

- .1 DESIGN: All wiring devices provided shall be Heavy Duty specification grade. New building devices will be ivory with stainless steel plates for standard and ground fault interrupter use on normal power. Isolated ground devices shall be orange with stainless steel coverplates. Wiring devices on emergency power shall be red with stainless steel coverplates. In existing building, designers shall match existing color scheme that is prevalent throughout building with the exception of emergency power. All emergency power receptacles added to existing buildings shall be red.
  - .1.1 Placement of Receptacles:
    - .1.1.1 In standard size classrooms (49 students or less) provide a double duplex receptacle at the front of the classroom centered under the chalkboard. Provide two additional receptacles at the front of the room spaced half way between corners and double duplex receptacles. Back of rooms to be provided with single duplex receptacle at center of wall and two additional receptacles equally spaced from corners. Remaining walls to be provided with two duplex receptacles on each wall equally spaced.
    - .1.1.2 Classrooms (50 students +) Provide two duplex receptacles for the front wall, centered between the corners and double duplex receptacle at the center of the wall. Provide two duplex receptacles equally spaced on all remaining walls.
    - .1.1.3 Corridors shall be provided with duplex receptacles 35' on center and a maximum of 15' from end of corridor. These receptacles shall have separate circuits and shall not be fed from the adjacent room circuits.

## DIVISION 26 – ELECTRICAL

---

- .1.1.4 Lecture halls shall be provided with a double duplex receptacle centered on the front wall and two additional double duplex receptacles equally spaced between center double duplex and corners. Provide duplex receptacle in floor for podium. Provide additional receptacles throughout for cleaning. These receptacles shall be a maximum of 25' on center. If lecture hall is provided with a lab bench, than provide bench with double duplex for every eight-foot of bench.
- .1.1.5 Computer Labs shall be provided with at least two general-purpose receptacles equally spaced per wall in addition to all receptacles for computers. These general purpose receptacles shall not be wired with computer equipment
- .1.1.6 Mechanical room shall be provided with at least four duplex receptacles (one per wall) and additional duplex receptacle where walls are 25' or longer.
- .1.1.7 Offices: Provide a minimum of one duplex receptacle per wall.
- .1.1.8 In utility tunnels receptacles shall be placed a maximum of 100' on center and a maximum of 25' from the entrance, exit or intersection of tunnel. These shall be GFCI type in NEMA 3R enclosures. These shall be located on the ceiling in line with the nearest light fixture.
- .1.1.9 In pedestrian tunnels, receptacles shall be a maximum of 100' on center and a maximum of 25' from entrance and/or exit. Receptacles shall be GFCI type and mounted 48" above the finished floor to the top of the receptacle.
- .1.2 Switches
  - .1.2.1 Switches provided for all uses shall be specification grade. Color scheme shall match receptacles.
  - .1.2.2 Switches provided at roof hatches or where provided outside of rooms they are serving shall be provided with pilot lights not lit handles.
- .1.3 Coverplates
  - .1.3.1 Generally coverplates for flush-mounted standard devices shall be stainless steel for interior use in new buildings. Where work is being performed in existing buildings coverplates shall match the majority of the existing devices.
  - .1.3.2 Coverplates for exterior use shall be type, which allow NEMA 3R rating to remain while in use. Where exterior device could be exposed to vandalism, provide locking type coverplates.

### 26 05 19 MULTI-OUTLET STRIPS

- .1 Multi-outlet strips for power or data and/or communications shall be two piece single channel steel capable of accepting full size heavy duty specification grade devices. It shall be provided with a standard ivory finish
  - .1.1 Minimum dimensions of single channel multi-outlet strip shall be 1.26" X 2.75".

## DIVISION 26 – ELECTRICAL

---

- .2 Multi-outlet strip for both power and data and/or communications shall be two piece channel multiple channel to keep power separated from data/and/or communications wiring.
  - .2.1 Minimum dimensions of two channel multi-outlet strip shall be 1.75" X 4.75".
- .3 Multi-outlet strips may be provided at laboratory benches, work benches and work counters in offices.
  - .3.1 Multi-outlet strips shall not be run through walls, fire rated or otherwise.

Commentary: Consider including duplex receptacles with USB ports where appropriate.
  - 3.2 Provide the University with 10% spare parts including but not limited to coverplates, elbows, entrance and end fittings, tees, utility boxes, etc.
- 26 05 29. HANGERS AND SUPPORTS
  - .1 MATERIALS FOR STRAPS AND HANGERS: Heavy-duty malleable iron or steel. For installation in locations above grade that are subject to moisture penetration, specify corrosion-resisting steel. Perforated straps are not acceptable.
  - .2 INDEPENDENT SUPPORT SYSTEMS: Required for all installations, except that light weight incandescent fixtures on, or recessed into, suspended ceilings may have adjustable bar strap supports carried on the ceiling suspension system.
    - .2.1 Surface outlet boxes, to which fixtures are attached, and pull boxes, shall be fastened to the structure independent of the conduit system supports.
    - .2.2 Conduits above suspended ceiling shall be attached to the structure and shall not be supported by a ceiling suspension system
  - .3 COORDINATION WITH GENERAL CONSTRUCTION: The A/E shall include the following (or similar) statements in specifications for suspended lay-in ceilings:
    - .3.1 Surface mounted fluorescent lighting fixtures shall be supported from the structure above independent of any ceiling system by use of 3/8 inch all thread rods.
    - .3.2 Flush or recessed fixtures in ceilings of the suspended lay-in type shall be installed so that the long dimension of the fixture is supported on the main support member of the ceiling system. Provide at least two galvanized steel safety hangar wires or safety chains, attached from the fixture housing to the structure independent of the ceiling system. Wire or chain shall withstand a 3-foot, 50-pound drop test. In addition the Luminaire Support Requirements of NEC shall be strictly followed.
- 26 05 33.10 INTERIOR CONDUIT AND FITTINGS: Minimum conduit size for power circuits shall be 3/4-inch. Minimum conduit sized for control wiring shall be 1/2 inch.
  - .1 RIGID GALVANIZED THREADED UL LABELED CONDUIT shall be specified for use in exterior walls, outdoors, for indoors exposed (surface) applications from floor level to 8-feet above floor, seal penetrations, and all the areas having potential to corrode or eat away by chemical-action (corrosive atmosphere) and hazardous locations.
    - .1.1 Threaded couplings shall be used with rigid conduit and I.M.C.
    - .1.2 I.M.C. may be used in place of rigid galvanized where permitted by The NEC
  - .2 UL LABELED, GALVANIZED STEEL EMT may be used in interior partitions, above ceilings, and for surface applications, except in mechanical and electrical rooms and shop spaces where it may be used 8'-0" from the finished floor.. In corrosive and hazardous locations, use fiberglass conduit.

## DIVISION 26 – ELECTRICAL

---

- .2.1 Insulating bushings and/or insulated throat fittings shall be used throughout EMT installations.
- .2.2 Compression fittings shall be used exposed below eight feet from finished floors. Setscrew type fittings may be used in other applications.  
  
Exception: Setscrew fittings may be used below eight feet if bolts are not pointing outward.
- .3 PLASTIC JACKETED RIGID STEEL CONDUIT shall be used in corrosive atmosphere.
- .4 FLEXIBLE CONDUIT used for motor make up and lighting fixture connections. Minimum size: 1/2-inch for lighting fixture whips and 3/4" for motor connections; maximum length: 6 feet 0 inches. Flexible conduit of any type shall not be used in interior partitions or in walls as a substitute for EMT, IMC or rigid steel conduit. A ground wire shall be pulled in all flexible conduit.
  - .4.1 Plastic jacket shall be used on flexible conduit exposed to outdoor or moist locations.
  - .4.2 Liquid-tight flexible metal conduit shall be used in raised floor computer room applications.
- .5 RIGID ALUMINUM CONDUIT shall be used outdoors, above grade, in damp locations and may be used in other locations in place of rigid steel conduit where corrosion is not a problem.
- .6 Conduit installed through a building wall shall have internal and external seals. Specify Linkseal or equivalent.
- .7 Elbows used for medium voltage cable shall be long radius rigid steel or if above grade, outside, rigid aluminum.
- .8 GROUNDING: Conduit crossing building expansion joints shall have expansion provision with grounding continuity.

### 26 05 33.11 BUSWAYS:

- .1 The A/E shall not use Feeder Busways in lieu of conduit and wire except for short distances inside substation rooms. Maximum length shall be 10 feet.
- .2 PLUG-IN BUS shall be used in shops where the load density provides an economic advantage over panels and shall not extend into more than one space. Plug-in bus shall be copper. Busway shall be used to serve one room or usable space. It is prohibited for busway to penetrate a fire rated wall. **Provide two spare bus plugs of each size installed.**
- .3 INDOOR BUSWAY (if used) shall be water resistant per ANSI/IEEE Standard 141-1986.
- .4 If use of busway is approved by special permission for a project, Contractor shall provide 50 feet of spare busway and 10% of total switches used. It includes when busway is installed in shop areas or specially approved conditions.

### 26 05 33.12 SURFACE RACEWAYS

- .1 The A/E shall specify Surface Raceway / Metallic Raceway with associated coupling, boxes and fitting to be mounted to the surface of structure for the installation of Electrical Conductors. It shall be used in the following locations:
  - .1.1 In dry locations.

## DIVISION 26 – ELECTRICAL

---

- .1.2 In Class I, Division 2 Hazardous (Classified) locations and as permitted by National Electrical Code (NEC).

### .2 FITTINGS AND BOXES

- .2.1 Raceway shall have manufacturer's finish standard prime coating suitable for field painting.
- .2.2 Surface Metallic Raceway. Metallic surface raceway shall be one piece construction, manufactured of .040" steel with smooth finish manufacturer's standard color. Minimum size to be ¾" X 2 1/32".
- .2.3 Surface Metallic Raceway shall be used in dry locations, extensions through walls, and shall be permitted to pass through drywall partitions and dry walls only if the length going or passing through is not broken. It is required that access to the conductors shall be maintained on both sides of the walls, partition and floor.
  - .2.3.1 The surface metallic raceway shall not be used where concealed, except as permitted by NEC. The use shall be limited to Class 2 power limited applications and communication.

### 26 05 33.13 UTILITY TUNNEL CONDUIT AND FITTINGS

- .1 INSTALLATION REQUIREMENT for corrosive and external heat generating environment.

The conduit must be suitable for the best protection from corrosion in the most demanding environments such as utility tunnels, under bridges, chemical, utility plants, underground pipeline, laboratories, electrical substations, and parking lots.

The conduits and the fittings must meet the requirements of UL 1684 that covers conduit type AG for use above ground and/or below ground, and type BG for use below ground applications. The University requires that the Manufacturer supply a letter from UL, not a "Certificate of Compliance," for the product to be approved for use in University facilities.

- .1.1 The preferred conduit and fittings shall be fiberglass reinforced epoxy manufactured using the filament process. The optional conduit shall be PVC coated rigid conduit that provides maximum protection against corrosion where fiberglass conduit usage is extremely difficult.

#### .1.2 FIBERGLASS CONDUIT AND FITTINGS

The Fiberglass Conduit and Fittings Standards cover the application Installation, and use of associated Fittings. The primary intent is to incorporate changes in technology and incorporate products that were not Proven or existing when earlier versions of the University Building Design Standards were published.

All Fiberglass Conduits shall be listed by Underwriters Laboratory, UL Std., and UL 1684.

- 1.2.1 The materials made or manufactured for use as conduits, raceways, boxes, cabinets equipment enclosures, and the finished product (Fiber conduits) shall conform to the latest edition of NFPA 130, NFPA 502, NFPA 70(NAC) and shall have capability to withstand high temperatures up to 500 degrees C or (- 60 + 932 degrees F) for minimum of one hour. The Fiberglass conduits requirements of the Standards shall include the followings:

- A. High Temperature Combustion Resistance

## DIVISION 26 – ELECTRICAL

---

- B. Low Smoke Zero Halogen.
- C. High Mechanical Strength.
- D. High Dimensional Stability.
- E. High Chemical Resistance.
- F. No impact from Stray currents.

1.2.2 The A/E shall make certain that the type of Fiberglass conduits specified are manufactured from epoxy resins that had flame resistance and low smoke characteristics, zero halogen and meeting the requirements of section 26 05 33 1.2-to-1.2.1 of this Standard

1.2.3 The fiberglass conduit shall be available in diameters  $\frac{3}{4}$ " to 6" and shall be UL Listed for use above and underground.

Again, the resin system shall be epoxy based using a hydride curing agent. The permitted fiberglass shall possess continuous E-glass roving. All additives for increasing flame spread and lowering smoke density must be halogen free (i.e. must not contain chloride or bromine).

The permitted type shall use carbon black as ultra violet inhibitor to protect the conduit and fittings during storage and if or when it is exposed outside.

### .1.3 FITTINGS AND ACCESSORIES

All fittings, elbows, and accessories shall be manufactured from the same process, using the same methods and chemicals as the pipe. The exceptions are plastic duct plugs and access fittings (often referred to as non-dailet fittings). Access fittings shall be made from fire retardant vinylester materials, halogen free, must be hot compression molded and shall have couplings attached to the body of the access fittings.

.1.3.1 The use of Fiberglass conduit shall be permitted for both below and above ground if requirements of Section .1.2.2 of this Standard is met:

- A. Tunnels
- B. In Class 1 Division 2 Installation( For Class 1 and Div2 Application "XW" fiberglass Conduit shall be used meeting the requirements of section 501.10(B) of National Electric Code, and UL 1684A Listed for above Ground use)
- C. Under Bridge Applications
- D. Plenum Areas
- E. Fire Pump Rooms
- F. Elevator Shafts
- G. High Temperature Applications.

.1.3.2 Cement for PVC conduit and fittings shall be as recommended by the PVC class 1 div 2 conduit manufacturer

### .1.4 OPTIONAL PVC COATED RIGID METAL CONDUIT

.1.4.1 The PVC coated conduit must be UL listed. The permitted PVC coating must have been tested and approved by UL as providing the primary corrosion protection for the rigid metal conduit.

## **DIVISION 26 – ELECTRICAL**

---

- .1.4.2 Applicable UL Standards may include: UL 6 Standard for safety, Rigid Metal Conduit, UL 514B Standard for Safety; Fittings for conduit and outlet boxes.
- .1.4.3 The PVC coated galvanized rigid conduit must be ETL Verified to the Intertek ETL SEMKO High Temperature H<sub>2</sub>O PVC Coating Adhesion Test Procedure for 200 hours. The PVC coated galvanized rigid conduit must bear the ETL Verified PVC-001 label to signify compliance to the adhesion performance standard.

### **26 05 45. UNDERGROUND RACEWAYS:**

- .1 **GENERAL REQUIREMENTS:** All underground cables of any classification shall be installed in raceway systems. Raceways for street lighting shall be 2" minimum. All other applications shall be sized in accordance with the projected electrical load growth in the vicinity but not less than 1.5". For conduit requirements in utility tunnels and under bridges Refer to Division 33.

### **26 10 00. SECONDARY/LOW VOLTAGE ELECTRICAL DISTRIBUTION**

#### **.1 MAGNETIC INTERFERENCE AND MITIGATION**

Magnetic Interference can pose major problems in the Design and Operation of Electrical and Electronic Equipment, Instruments, Control Systems, Data processing equipment and communication networks. This equipment frequently indicates aberrations whose sources may not be readily recognized, but which are due to magnetic interference. In general, such interference is classified as internal and external.

- A. Internal Interference, created by Operation of Components within the system itself, can usually be eliminated or nullified by shielding the individual components and confirming the magnetic force they create.
  - B. External Interference is frequently caused by nearby or adjacent equipment such as transformers, medium voltage busway, or switching equipment, which generate magnetic "spikes" affecting apparatus which is not physically attached to the source of interference.
- .1.1 **Special Protective and Preventive materials:** In addition to developing a basic protection design in preventing the penetration of magnetic interference, when it is required by this Standard to Design and specify EMF Mitigation Plans or Strategies that will prevent and solve the Magnetic Interference problems as described in Section 26 10 00.1. The expectation of this Standard is to reduce EMF to below one (1) milligauss, even in the most complex Field Environment.
  - .1.2 **SPECIAL EMF SHIELDING MATERIAL:** There are two means of EMF Shielding that may be used to achieve effective prevention of Magnetic Interference or Eliminate the existing problems (See Section 26 10 00.1.1 and 26 10 00.1.3).

In fields of low intensity, use CO-NETIC AA perfection sheet because of its high initial permeability and corresponding high attenuation characteristics. In fields with high intensity, use NETIC S3-6 sheet because of its high magnetic saturation characteristics. CO-NETIC AA Perfection Annealed Sheet are available in standard gauge .014" through .062" thick, in flat sheet sizes up to 30"x59" or Full Sheet of .015" thick and 36" by 120".

## DIVISION 26 – ELECTRICAL

---

Installation: For wall or floor coverings designer shall specify that sheets shall be butted at seams, all seams flush and tight.

Fasteners: NETIC/CO-NETIC AA Sheets shall be mounted to walls by non-magnetic fasteners to penetrate the shielding sheets. Hole in the NETIC/CO-NETIC AA alloy sheets for fasteners shall be drilled with standard metal drills (Cobalt Steel Drill Bits). Special fastening application (masonry, concrete, etc.) shall be consistent with EMF shield manufacturer's recommended attachment procedures and OSU Building Design Standards requirements.

Seams: All seams between sheets to be covered by CO-NETIC AA foil, 0.01 inches thick, by 4 inches wide, with factory supplied PST backing. Apply foil centered over the sheet seams and press down tightly.

Finishing: The CO-NETIC AA metal has a natural shiny, silver colored finish and will not rust. Gypsum Wallboard (drywall) or approved other materials shall be applied over the CO-NETIC AA sheets after seams are covered. No magnetic fasteners are to penetrate the CO-NETIC AA sheets.

- .1.3 OPTIONAL SHIELD MATERIAL: The use of ferrous metal sheet for EMF shielding has been one method the University utilized for correcting EMF problems. But it has unavoidable installation difficulties for inexperienced installers. The sheet metal sheet is too heavy, requires accurate overlapping to achieve minimum EMF reduction, but it is very effective, if correctly installed.

Installation: All Medium voltage transformers and switch gear including motor control centers that are adjacent to or under offices, computer centers/rooms or locations that will have the use of Sensitive Electronic Equipment (SEE) shall be shielded with ferro-magnetic material.

Use of minimum 10 gauge ferrous steel sheet metal on the side(s) of walls where said offices or rooms are situated, to prevent moving charges that produce Electric Magnetic Field (EMF) penetration that in turn destroys or distorts sensitive electronic equipment.

In order to have an effective shielding, the 10 gauge sheet metal shielding shall be overlapped at a minimum of 4 inches at every joint.

- .1.4 A/E's electrical consultant(s) shall contact the University Engineer for details, if there should be any questions.

### .2 TRANSFORMERS - UNDER 600 VOLTS

- .2.1 General-purpose distributing transformers shall be single-phase and three-phase dry-type which are generally used with primaries connected to secondary distribution circuits. They shall be designed for the voltages of 120, 208, 240, 480, and 600 with ratings ranging from 500VA to 500KVA and frequency of 60Hz.

- .2.2 The transformers shall be designed for continuous operation at the rated KVA for 24 hours a day, 365 days a year operation with a nominal life expectancy and greater overload capabilities in accordance with the latest ANSI-C57. The temperature rise of these transformers shall be 80 degrees C temperature rise and shall be insulated with a UL recognized 220 degree C insulation system. Transformers shall have k factor rating as recommended by ANSI/IEEE C57.110-1986, where required (i.e. computer center, lab, etc.). It shall have a 30 percent overload capability.

- .2.3 The transformers shall be designed for a low coil watt loss.



## **DIVISION 26 – ELECTRICAL**

---

- .2.4 Coil and Core Assemblies
  - .2.4.1 Transformer cores shall be constructed with high grade, non-aging, grain-oriented silicon steel with high magnetic permeability, low hysteresis and eddy current losses.
  - .2.4.2 Transformer coils shall be wound of electrical grade copper and continuous wound construction. The neutral conductor shall be rated to carry 200% normal phase current, when required.
  - .2.4.3 Enclosure shall be ventilated, heavy gauge sheet steel primed and finished in gray baked enamel. The core and coil assembly of the transformers shall be impregnated with non-hygroscopic, thermosetting varnish and cure to minimize hot spots and seal out moisture. The core of the transformer shall be grounded to the enclosure.
  - .2.4.4 The sound levels of the transformer shall be designed in accordance with ANSI/NEMA recommended levels.
  - .2.4.5 Provide minimum clear working space of 3 ½ feet (3 ½') about transformers operating at 600 volts, nominal, or less to permit ready and safe operation adjustment, repair and maintenance.
- .2.5 Transformers greater than 25 KVA shall not be mounted on or near the wall adjacent to an office, computer room or laboratory unless the wall is magnetically shielded.

### **26 20 00. LOW-VOLTAGE ELECTRICAL TRANSMISSION**

- .1 EMERGENCY SERVICE: Refer to Section 26 30 10.

### **26 20 03. LOW-VOLTAGE SWITCHGEAR – SERVICE ENTRANCE**

- .1 PROTECTIVE DEVICES: Main breakers and feeder breakers or switches shall be equipped with ground fault protection as required by applicable codes. In critical applications provide coordinated ground fault protection on feeder breakers. Provide settings and coordination information with the service manuals.

- .1.1: Where applicable the following warning sign shall be provided:

WARNING: SHUTTING OFF OF MAIN SWITCH DOES NOT SHUT-OFF  
POWER IN ENTIRE BUILDING.

Provide the following additional information as applicable:

- A. ADDITIONAL MAIN SWITCH IS LOCATED IN ROOM O30M  
IN THIS BUILDING
- B. AUTOMATIC TRANSFER SWITCH LOCATED IN ROOM  
530M IN THIS BUILDING AND EMERGENCY  
GENERATOR IS LOCATED IN ROOM 036M OF MATH  
TOWER.

Include building and room number if emergency source is not in the same building as the main switch.

- .1.2 All circuit breakers with solid state trip units shall comply with the following standards:
  - .1.2.1 ANSI/IEEE C37.90.1 – Surge Withstand Capability (SWC)

## DIVISION 26 – ELECTRICAL

---

- .1.2.2 ANSI/IEEE C37.90.2 – Withstand Capability of relay systems to Radiated Electromagnetic Interference from transceivers.
- .2 The maximum operating force required to open or close a switch or breaker shall not be greater than 75 pounds on the operating handle.
- .3 Vacuum breakers or vacuum switches may be used with the approval of the University Engineer's Office.
  - .3.1 All switches shall be top or horizontal fed to the breakers
- .4 Indicator lamps shall be LED or transformer type utilizing low voltage lamps.
- 26 20 04. METERING: Refer to Division 33
- 26 20 05. SERVICE DISCONNECTS:
  - .1 Secondary main disconnects shall be equipped with electronic trip devices.
    - .1.1 The analysis diagram fault currents shall be shown on a symmetrical basis; and for calculation purposes, the transformer primary available fault supply shall be considered as unlimited.
  - .2 FUSES may be used in primary-voltage services, secondary-voltage main switchgear, distribution panelboards, and motor controls.
    - .2.1 UL classification fuses shall be used as required for time delay and current limitation requirements of the application.
    - .2.2 Class J fuse is prohibited with the exception of elevator power modules. Use class RK1, 200,000 AIC rated fuses for up to 600 amp applications and RK1 for maximum short circuit protection.
    - .2.3 Fuses for secondary service mains and feeders over 600-ampere shall be UL Class L.
    - .2.4 Spare Fuses: Specify that a spare fuse complement be stored on existing metal shelves, metal mounting boards, or in a cabinet in the electrical switchgear room and that a typewritten and framed bill of material is mounted nearby. If there is no existing storage or additional storage space is required, specify that Contractor provide a cabinet equal to Bussmann SFC and provide hardware to accept BEST 7 pin interchangeable lock cores.
      - .2.4.1 Spare fuse complement shall include a minimum of three or 10% of the total each (whichever number is greater) spare fuses of each class, ampere, and voltage rating installed, including primary fuses and control circuit fuses in switchgear and any equipment.
      - .2.4.2 Provide two fuse pullers for every size fuse and voltage rating.
- 26 20 06. GROUNDING SYSTEM:
  - .1 DRAWINGS AND SPECIFICATIONS: Drawings shall show ground systems, protective conduit sizes, and relative locations. Specifications and drawings shall include detailed requirements of the grounding system. **A reference only to the National Electrical Code, without elaboration, has proven to be insufficient. Specifying requirements only by referencing the National Electrical Code is prohibited. It is required that the A/E shall specify all requirements applicable, instead of referring only to National Electrical Code.** All sensitive electronic equipment (computer rooms, etc.) shall have single point grounding system.

## DIVISION 26 – ELECTRICAL

---

All connections to the grounding system shall be clamped, exothermic welded, cad weld or equivalent. It is required that the grounding system be tested and have a resistance reading of less than 3 ohms at the ground level. Only copper to copper may be clamped. The A/E shall calculate the system required to obtain 3 ohms. The contractor shall only be required to install the indicated system.

- .2 SERVICE GROUND: Grounding rods shall be a minimum size of 5/8" x 10' copper clad steel and shall not be placed in back-fill. It shall meet current NEC requirements and other applicable codes.
- .2.1 Interconnection of the service ground, system neutral, and equipment ground conductors shall be made within the service equipment.
  - .2.2 Grounding path through feeder conduits must be kept at less than five ohms resistance. The entire feeder conduit shall include a grounding conductor. The equipment enclosure (transformer case, etc.) shall not be used as a grounding path.
  - .2.3 Grounding conductors shall be 600-volt insulated installed in rigid PVC or rigid galvanized conduit. No metal parts such, as locknuts shall surround the ground conductor. If metal is used, protective conduits for ground conductors shall be bonded at both ends to reduce impedance in the ground path under fault current flow. All conduit connections shall be threaded and then welded.
  - .2.4 LIGHTNING PROTECTION: It is well documented that insulation levels of overhead lines is considerably higher than insulation levels of terminal apparatus including transformers, switchgears, pothead, etc. which make up or comprise the service entrance to buildings. Such overhead lines (University overhead lines at Airport, West & Midwest, and Regional Campuses) are vulnerable to over voltage, mostly from direct or indirect lightning voltages and switching surges. It is a fundamental characteristic of the traveling voltage waves to increase in voltage when they arrive at equipment having a surge impedance higher than that of incoming line and the magnitude of such incoming waves will approximately double at breaker. Therefore, this standard requires that all equipment connected by cable to overhead circuits shall have lightning/surge arrester protection at each end of the cable to guard against the possibility of transient over voltages. It is of great importance that protection against direct strokes is provided at outdoor substation installations in the form of grounded **masts** or overhead ground wires stretched above the installation to intercept lightning strokes, which might otherwise terminate on the lines or apparatus. It is also required that entrance equipment such as transformers, circuit breakers, etc be protected against direct stroke from traveling waves by installing lightning arresters that possess protective characteristics below the impulse insulation strength of the terminal apparatus.
    - .2.4.1 This standard requires that lightning/surge arresters be installed as close as possible to the HV/MV terminals of the Power Transformer and all other equipment requiring surge protection be grouped as close as possible to the arresters. Use the station type arrester for the best protective level and highest surge discharge ability for important and critical installations. But the intermediate class type arrester shall be used for less critical installations and mostly for feeder protection.
    - .2.4.3 This standard requires the following additional protective measures:
      - A. Grounding network resistance shall not exceed 5 Ohms (5Ω). Lower values are preferred.
      - B. Ground Conductors: The surge arrester grounding conductor shall be connected into the common ground bus. The grounding

## DIVISION 26 – ELECTRICAL

---

conductor shall be run as directly as possible between the arresters and ground and be of low impedance and ample current carrying capacity. (See Section 26 20 06.2.4). These requirements must comply with National

Electrical Code. (ANSI/NEMA 81-1990 (19, Article 190-193)).

- C. Indoor locations: Arresters that are installed inside the buildings shall be enclosed or shall be located well away from passageways and combustible parts.
- D. Installation: This standard requires that arresters must be located and installed in such a manner that the expulsion of gales or the arrester disconnect is not directed upon energized parts.
- E. All protective lightning rods used for building or facility protection must have a Master Label pasted on them.

.2.4.4 A/E shall require electrical contractor to provide resistance testing. Testing shall be witnessed by the A/E and the university project manager. Test results shall be recorded on contractor's letterhead and submitted as part off the Operation and Maintenance Manuals.

### .3 TRANSFORMER GROUNDS:

.3.1 Building Service Transformers: Secondary neutrals shall be grounded separately from the neutral ground at the service main, unless close coupled in unit substation construction.

.3.2 Low Voltage Transformers: Secondary neutrals shall be grounded in the low-voltage service equipment, as required by NEC for services

### .4 EQUIPMENT GROUNDS: A wire equipment ground shall be installed within the branch circuit conduit and be grounded to the cabinet of the panelboard to a non-insulated ground bus. The neutral bar of the panel shall not be used for equipment grounds.

.4.1 Equipment grounds and the identified neutral shall not be electrically interconnected on the building side of the service ground.

### .5 CONVENIENCE OUTLETS: Specify that a wired ground be provided for continuity of ground path from the device-grounding pole. Provide ground fault interrupter outlets in wet conditions and where required by NEC and other related codes.

### .6 EXTERIOR LIGHTING POLE: For steel-framed structure, explore a concrete-encased reinforcing bar electrode. A steel rod similar to the reinforcing bar shall be used to join, by welding, a main vertical reinforcing bar to an anchor bolt. The bolt shall be permanently connected to the base plate of the steel column supported on that footing. The Electrical System may then be connected for grounding to the building frame by welding or by a bronze bolt tapped into a structural member of that frame. For Electrical Systems grounding, specify that ground rod or ground copper wire is provided for equipment grounding at each light fixture. All underground PVC conduits to the light poles shall contain a dedicated ground copper wire in combination with equipment grounding. It shall be designed to provide a safe method of protecting electric distribution systems by causing the overcurrent or ground fault protective equipment to disconnect the circuit in case of ground fault.

## 26 27 00. LOW-VOLTAGE DISTRIBUTION EQUIPMENT

## DIVISION 26 – ELECTRICAL

---

### 26 27 03. DISTRIBUTION:

- .1 DESIGN: If feasible, the secondary main breaker shall be made a part of the building distribution switchgear or switchboard. In no case shall the switchgear or switchboard or panelboard be directly attached to the transformer. A minimum 12-inch space with solid barrier is required to reduce the transfer of transformer heat to the low voltage section. Reduction of heat transfer may be accomplished with secondary throat or ventilated transition section.
- .1.1 Tiebreakers, if used, shall be key interlocked with the main secondary disconnecting means requiring the spare key to parallel sections.
- .2 EQUIPMENT: Metal-Enclosed switchgear or distribution boards shall be used in buildings or University Facilities at 600V and below for Service Entrance Power, lighting distribution and as the secondary sections of Unit Substations. The following components shall be specified as required:
- A. Service Protectors
  - B. Model-Case circuit breakers, group, or individual mounted.
  - C. Fusible switches
  - D. Motor Starters
  - E. Low Voltage AC Power circuit breaker (generally limited to main or tie position)
  - F. Bolted contact pressure switches
  - G. Transfer devices or switches
  - H. Instrumentation, metering and relaying
- .2.1 Type of Molded Case Circuit Breakers: These devices are available in the following general types: Thermal-Magnetic Dash Pot, Magnetic only, Integrally Fused, Current Limiting, and High Interrupting Capacity. It is required that all circuit breakers that are equipped with solid state trip unit must comply with Section 26 20 03.1 of this Standard.
- .2.1.1 Air circuit breakers shall be draw out type, installed in individual compartments.
- A. Interrupting ratings of air circuit breakers and molded case breakers shall not be applied in "cascade".
- .2.2 The handle operating force on all equipment shall be 75 pounds or less.
- .3 PROVISIONS FOR ADDITIONAL CIRCUITS:
- .3.1 Size of Switchgear or switchboard: Select a size that will provide sufficient spare spaces, complete with bus and hardware, for a reasonable forecast of future installation of circuits. A minimum of one fully bussed spare section shall be provided. Provide the following spare devices at the design stage:
- |                          |                                  |
|--------------------------|----------------------------------|
| For Fusible Switchboards | For Circuit Breaker Switchboards |
| four 30 amp/ 3 poles     | ten 100 amp/3pole*               |
| four 60 amp /3 poles     | one 225 amp 3/pole*              |
| two 100 amp / 3 poles    |                                  |

## DIVISION 26 – ELECTRICAL

---

one 200 amp /3 poles

\*with adjustable trips

.3.2 Additional Section: Provide space and the bus arrangement for the addition of future switchgear or switchboard sections.

.4 INSTRUMENTATION shall be per section 26 20 04. Metering.

.5 SERVICE TO FIRE PUMPS: Fire pumps shall be served and protected as required in NFPA No. 20.

.6 Use switchboard instead of panelboard for emergency systems for the purpose of future growth and expansion. The switchboard shall be equipped with metering systems as required in Division 33 of this Standard.

.7 When adding switches, circuit breakers, bus plugs or motor starters to existing equipment, the A/E shall include the following on his/her design documents:

.7.1 The manufacturers' nameplate data including manufacturer, catalog information and order number of the existing equipment.

.7.2 If the equipment is no longer being manufactured (i.e., Continental, Arrow Hart, Crouse Hinds, etc.) the A/E will contact a company that specializes in obsolete equipment and obtain information about availability of equipment and mounting for the bidding of the project.

.7.3 The A/E will provide appropriate staff and equipment during the design phase to open equipment to verify equipment has bussing, capacity and actual space to allow addition of switches, circuit breakers and/or starters.

26 27 04. FEEDER CIRCUITS:

.1 SYSTEM DESIGN: Design feeders for a voltage drop of not more than 2 percent between terminals and capacity for 30 percent load growth above initial design, unless greater growth is designated by the University in the initial planning conference.

.2 FEEDERS: Feeder ratings shall not be such a large percentage of the main that coordination of time and current and interrupting capacities cannot be achieved.

.3 WIRING: Specify that all feeders be installed in full-weight rigid conduit.

26 27 05. GENERAL PURPOSE POWER AND LIGHTING CIRCUITS: Voltage drop in branch circuits must be considered in design. Increase conductors a minimum of one size when 120 volt branch circuit home runs exceed 75-feet.

.1 LIGHTING CIRCUITS shall not be loaded to exceed 70 percent of panel breaker rating.

.2 SERVICE CIRCUITS: Not more than six unassigned general use duplex convenience outlets shall be on any one 20-ampere branch circuit, which includes prewired furniture, and lecture hall tables.

.2.1 Corridor receptacles shall not be connected to any adjacent room receptacles.

.3 BRANCH CIRCUIT PANELS: Panels for lighting, convenience outlets, small motors, and equipment shall be molded case circuit breaker type with thermal-magnetic trip and a-c and d-c ratings. Minimum number of poles in any panel enclosure shall be 42. Maximum number of poles shall not exceed 84. Provide spare circuits and spaces as noted in paragraph .3.3.1 below.

## DIVISION 26 – ELECTRICAL

---

- .3.1 Breakers shall be 20-ampere, 1-pole breakers, mounted in the panel with bolted bus connections.
  - .3.1.1 Trip rating of breakers for lighting and general use convenience outlets shall be 20-ampere. Provide other sizes as required for special loads.
- .3.2 Sub-Feed Breakers: Panels shall not have sub-feed breakers. If two panels are supplied from a long feeder, use sub-feed lugs or separate splice box with full size tap to panel mains. **(no panel feeder shall feed more than 84 poles)**
- .3.3 When installing new branch circuit lighting panels on a project the following shall be considered:
  - .3.3.1 All new panel enclosures shall be 42 pole minimum. Designers shall provide each new panel with a minimum of 15% spare 20 amp single pole circuit breakers and 15% spaces. Designers shall consider an additional panel when these minimums cannot be met. **Phases shall be balanced as close as possible.**

***Commentary:** An example is for poles 31 through 41 (odd) to be 20 amp, 1 pole spares and poles 32 through 42 to be spaces.*
  - .3.3.2 New panels shall be 200 Amp minimum for 208Y/120 volt, 3 phase, 4 wire service and 100 Amp minimum for 480/277 volt, 3 phase, 4 wire service. Do not provide 240/120 volt, 3 phase, and 4 wire tapped delta systems. Where 240 volts, 1 phase is needed, Use buck/boost transformers as required.
  - .3.3.3 Any new or existing building with three-phase service shall only have three phase panels provided. All exceptions must be approved by the University Engineer.
  - .3.3.4 Do not provide panel feeders, fusing, or main circuit breakers at less than the panel main device rating.
  - .3.3.5 Branch circuits shall not be provided with shared neutrals regardless of what is existing in the facility.
  - .3.3.6 Where multiple branch circuits pass through a single box, all circuit breaker handles shall be provided with common tie, so all circuits will be taken out of service for servicing of the circuits.
- .4 POWER PANELS shall be equipped with molded-case circuit breakers of adequate interrupting capacity, or shall be switch and fuse construction using time-delay fuses.

### 26 29 00. LOW VOLTAGE CONTROLLERS

#### 26 29 03. MOTORS AND MOTOR CONTROLS:

- .1 RELATED WORK: Air-conditioning chiller starters and fire pump controllers shall be specified with the equipment in Divisions 23 and 21. Wiring from switchgear or switchboard to this equipment shall be specified in Division 26.
- .2 NEMA AND NEC REQUIREMENTS:
  - .2.1 MOTORS AND MOTOR CONTROL EQUIPMENT shall conform to NEMA voltage ratings.
  - .2.2 MOTOR BRANCH CIRCUIT PROTECTIVE DEVICES shall meet the requirements of NEC 430.

## **DIVISION 26 – ELECTRICAL**

---

- .3 MOTOR CONTROL CENTERS: Class I, Type C with terminal strip terminations.
  - .3.1 LOCATIONS: Centers shall not be located where ambient temperature could cause de-rating of overload devices.
  - .3.2 OVERLOAD HEATER CHARTS shall be furnished mounted inside doors of cabinets or separately framed and mounted outside the equipment.
- .4 REDUCED VOLTAGE STARTERS: Motors, sizes shall be such that the inrush current exceeds 40 percent of the building transformer rating. Motors shall be equipped with reduced voltage starters of the closed transition auto transformer or star-delta type, or solid state soft start, or current ramp starters.
- .5 OPERATING PROTECTION:
  - .5.1 CERTIFICATION by the motor manufacturer that motors meet the voltage requirements of NEMA.
  - .5.2 OVERLOAD RELAYS: Poly-phase motor controls shall be equipped with three overload relays. Reduced voltage starters shall provide overload protection during the starting step.
- 26 29 05. MOTOR STARTER APPLICATIONS:
  - .1 TYPE OF STARTERS: Alternating current (AC) magnetic-fused-type starters, NEMA Class E2 in accordance with ANSI/NEMA ICS2-1983(26) shall use current limiting power fuses and magnetic air break contactors. Each starter shall be completely self-contained, pre-wired, and with all components in place. Air break contactors if employed shall be current rated based on motor horsepower requirements. It is important to know as a guideline that combination starters will provide an interrupting fault capacity of 260MVA symmetrical on a 2300V System, and 520MVA symmetrical on a 4160 or 480V System. This starter must comply with ANSI/NEMA ICS2-1983 (26), Class E-2 controllers NEC 2005-760 and applicable IEEE and current ANSI Standards.
    - .1.1 Starters for 600V and below, the design must conform to ANSI/NEMA ICS2-1983(26). This is a requirement for magnetic controller ratings of 115-575V. AC Motor starters and contactors may be used for controlling the circuit to the motor. This standard requires that starters should be carefully applied on circuits and in combination with joint short-circuit protective devices such as circuit breakers, fusible disconnects that will limit the available fault current and let through energy level that starter can safely withstand. This withstand must meet the requirements of ANSI/UL 508/1983(29), and ANSI/NEMA ICSI-1983(25), (26) which cover controls, systems, and devices.
    - .1.2 The starters shall not be used without an adjacent line-switch. A non-fused disconnect switch shall be installed; and shall be located as close to each motor as much as possible. This standard forbids the installation of a remote switch with lock arrangement, at switchgear, switchboard. Panel board or a unit in a Motor Control Center.
    - .1.3 All rooftop mounted equipment shall be provided with a local disconnect switch.

### **26 30 00. FACILITY ELECTRICAL POWER GENERATING AND STORAGE EQUIPMENT**

#### **26 30 10. EMERGENCY POWER SYSTEMS:**



## DIVISION 26 – ELECTRICAL

---

- .1 ALTERNATE POWER SOURCES: The University Master Plan provided for connecting groups of buildings with parallel power circuits for obtaining electric power supply to a building from alternate sources. Where the interruption of electric power supply to a building would result in hazard to life or property, major loss of research or equipment, provision shall be made for an emergency supply of power, to be used in the event of failure of the normal supply. Details of the plans as they apply to the project shall be explained and included in the early **Design/Development** submittal and conferences. If tie-in on existing circuit or feeder is not practical at present, provision shall be made for future tie-in. Emergency Power Systems are of two basic types:
- A. An Electric Power Source set apart from the Prime Source of Power Operating in parallel that maintains power to the critical loads should the Prime Source fail.
  - B. An available reliable Power Source to which critical loads are rapidly switched automatically when The Prime Source of Power fails. (AC Source)
- .1.1 References
- A. NFPA 110 Emergency and Standby Power Systems
- .1.2 Automatic Transfer Equipment: Reliable equipment and transfer switch must be specified.
- .1.3 When emergency generators are specified, the A/E shall specify to include requirements for demonstrated load tests by a factory representative.
- .1.4 Provide identification labels showing normal, emergency, and connected load sources along with building name and room numbers for any automatic transfer switches.
- Commentary:** *Identification labels shall provide the following information:*
- A. Normal Service – source, building (if different then building in which automatic transfer switch is located) and room number Label shall be black with white lettering.
  - B. Emergency service - source, building (if different then building in which automatic transfer switch is located) and room number. Label shall be red with white lettering.
  - C. Emergency load - source, building (if different then building in which automatic transfer switch is located) and room number Label shall be red with white lettering.
- .2 Emergency and Standby Systems: It is required that provision be made by designing an emergency power system / standby power source supplied by:
- A. Engine Generator
  - B. Separate Emergency Source

**Commentary:**

*Emergency power systems are defined as systems which are intended to automatically supply illumination, power or both, to designated areas and equipment in the event of failure of the normal supply or in the event of an accident to elements of a system intended to supply, distribute and control of illumination essential for the safety to human life.*

*Standby Power systems is defined as providing power to loads that upon loss of power during any interruption of the normal electrical supply could create hazards or hamper rescue or fire - fighting operations.*

## DIVISION 26 – ELECTRICAL

---

- .2.1 Emergency electrical systems shall provide power to but not limited to the following essential electrical functions:
  - 1. Life safety Illumination
  - 2. Fire detection and alarm systems
  - 3. Elevators
  - 4. Fire Pumps
  - 5. Public Safety communications systems
  - 6. Essential Ventilating and smoke removal systems
  - 7. Processes where current interruption would produce serious life safety or health hazards
  - 8. Maintaining Business Continuity
- .2.2 Standby electrical systems shall provide power to but not limited to the following functions:
  - 1. Heating and Refrigeration systems
  - 2. Communications systems
  - 3. Sewage Disposal
  - 4. Lighting
  - 5. Industrial processes.
  - 6. Generators provided for dedicated lab equipment
- .2.3. Circuit breakers provided with generators shall be provided with lock out tag out capabilities.
- .2.4 Emergency generator drives shall be evaluated on a project by project basis.
- .2.5 The NFPA 110-5.6.6 required generator remote annunciator monitoring panel by shall be located next to the fire alarm remote annunciator panel.
- .2.6 Emergency generator fuel type shall be reviewed and evaluated with FOD Utilities Department and approved by the University Engineer.

**Commentary:** Diesel is considered to be the primary fuel type for emergency generators. Natural Gas may be considered, but the impact of limited fuel source and business continuity shall be evaluated.

.2.6.1 Location of the generator shall be reviewed with the University Engineer University Architect and University Landscape Architect to determine the best location. The University's preference is for the generator(s) to be placed at grade level.

**Commentary:** Points to consider include but are not be limited to the following:

- A. Flood Plain
- B. Esthetics
- C. Grade Level
- D. Maintainability

.2.6.2 If the generator cannot be located at grade level the following provisions shall be provided:

- A. A path from the generator shall be provided with conduit(s) and conductors to allow for connection to a future temporary generator. Provide a quick connect generator switchboard with quick connect cables of

sufficient conductor length so that no additional conductors shall need to be provided.

- B. Provide three 120 volt 20 amp circuits from an emergency source adjacent to the quick connect generator switchboard should a temporary generator need to be provided.
  - 1. One circuit shall be for a temporary battery charger
  - 2. One circuit shall be for a temporary block heater
  - 3. One circuit shall be for engine status.
- C. An internal load bank shall be provided for all buildings where generators are not located at grade level.
- D. A path and any required equipment (i.e. pumps, above ground tank, appropriate piping, etc.) for the filling of fuel for sub base or day tanks shall be provided when the diesel generator is not located at grade level.
- E. Provide an automatic shutoff for the fuel line if fire is sensed at the tank.

.2.7 A/E shall only specify above ground, sub base or day tanks for fuel storage. Underground tanks are prohibited. A spill control kit shall be provided near any tank, See 2.5.5 for details.

.2.7.1 Storage tank fill pipe shall have a cap that shall accept a padlock. (Padlock shall be furnished by the University)

.2.7.2 Above ground tanks placed outdoors shall be placed inside secured screened areas. Location of tanks shall be approved by the University Architect and University Landscape Architect in consultation with the University Engineer.

.2.7.3: The above ground tanks shall be either of the following:

- A. Double walled construction or
- B. Located in a secondary containment curb that can contain entire (110% if outdoors) tank contents.

.2.7.4 The A/E shall ensure that the University Project manager is provided with information relative to any fuel storage tank and the tank installation. University project manager shall share this information with OSU-Environmental, Health and Safety group.

.2.7.5 Spill control kits shall be stored in a 20 gallon yellow drum and contain the following items as a minimum:

- One (1) Gallon of Super absorbent (ENSORB(R) or equal)
- Six (6) 42" socks
- Fifty (50) 15" x 20" absorbent pads
- Two (2) pairs of Nitrile Gloves
- Two (2) pairs of Goggles

## DIVISION 26 – ELECTRICAL

---

- Two (2) 18" X 30" disposable bags and ties
  - One (1) emergency response guide
  - One (1) Instruction Sheet and Safety Data Sheets
- .2.8. Contract Documents shall include the following in addition to any other requirements of the code.
- A. Proper distances shall be provided from buildings, property lines, pedestrian traffic, building air intakes, and storm outlets.
  - B. Spill control shall be included via either double wall or secondary containment.
  - C. Above grade tanks shall be installed inside a secure screened area that is lockable and approved by the university Architect.
  - D. Provide permanently placed bollards for vehicular barrier protection.
  - E. An overfill prevention mechanism alarm monitoring system shall be provided
  - F. Provide a spill container to capture overfill at the fill connection locations.
  - G. Storage tanks shall be grounded
  - H. Feed lines shall be engineered to be protected from rupture and corrosion.
- .2.9 Generators shall not be cooled using "Potable water".
- .2.10 Generator battery chargers and block heaters shall be connected to an emergency power panel.
- .2.11 Emergency lighting shall be included at the generator location, in all mechanical equipment spaces, and in electric transformer and switchgear or switchboard spaces. Substation lighting and receptacles shall be included on the emergency system.
- .2.12 Electrical Equipment fed from an emergency generator or any two sources shall be tagged with a red label and white lettering.
- A distinctive warning sign shall be provided indicating the location of both sources of power.

**Commentary:** *Signage at an automatic transfer switch may be similar to the following:*

*NORMAL SERVICE – MAIN SWITCHBOARD MSB IN LOCATED ROOM 7M IN THIS BUILDING*

*EMERGENCY SERVICE - EMERGENCY SWITCHBOARD ESB LOCATED IN ROOM 35M IN THIS BUILDING*

*EMERGENCY LOAD LOCATED IN ROOM 10M IN MATH TOWER.*

### 2.13 Generator batteries

- A. Batteries shall be maintenance free heavy duty type.

## DIVISION 26 – ELECTRICAL

---

- B. Lead acid storage battery set of heavy duty diesel starting type.
- C. Battery set shall be compatible with the starting system and voltage.
- D. Provide sufficient capacity for 1.5 minutes of total cranking time without recharging being required.
- E. Provide the following items as required:
  - .1 Battery rack, cables, clamps and removable cover
  - .2 Battery heater pads

### .2.14 Battery Chargers

- A. Battery chargers shall be current limiting type and shall recharge the batteries automatically.
- B. The battery charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell.
- C. Chargers shall be provided with overload protection, silicon diode-full wave rectifiers, voltage surge suppression, DC ammeter and fused AC input.
- D. AC input voltage shall be 120 or 277 volts pending on the source available +10%.
- E. Amperage output shall be no less than 10 amperes
- F. Charger shall be provided with charger/battery failure alarm and dry contacts output to generator controller.

### .2.15 Environmental Considerations

- .2.15.1 The engine shall be EPA-certified with an accessible and readable nameplate. Provide complete documentation that the engine meets all US EPA requirements. A copy of this documentation needs to be provided to the project manager for transmittal to OSU-EHS.
- .2.15.2 Provide specifications for the emergency generator to the university project manager to furnish to OSU-EHS. OSU-EHS will obtain the necessary permit-by-rule (PBR) for the generator from the Ohio EPA.
- .2.15.3 Show location and specifications for the exhaust from the emergency generator. OSU has specific Building Design Standards relating to rooftop exhaust stacks. See Appendix V
- .2.15.4 Batteries shall be located such that any potential leakage is contained and any supporting structure/concrete will not be damaged.

.2.16 A/E shall include commissioning elements in the project manual.

### .2.17 On site load testing of emergency generators

.2.17.1 Provide a minimum of two hour on site load test after generator is installed.

.2.17.2 The generator will be tested the first half hour at 50% load

.2.17.3 The second half hour shall be tested at 75% load.

.2.17.4 The final hour of testing will be at 100%.

***Commentary: The load test may be expanded to four hours at the A/E's discretion***

.3 AN EMERGENCY PANELBOARD shall be provided for:

- .3.1 Exit lights.

## DIVISION 26 – ELECTRICAL

---

- .3.2 Minimal hallway and stairway lighting and telephone power.
  - .3.3 Fire alarms, building security equipment, and fire protection systems; this does not eliminate the need for batteries. Batteries shall be tested to indicate amp-hour availability. The Manufacturer shall provide documentation that indicates conformance with repaired rating to the University.
  - .3.4 Elevators and/or elevator rooms when required by OBC.
  - .3.5 Traffic signals fed from the building.
  - .3.6 EMERGENCY ILLUMINATION: Emergency illumination shall be part of emergency lighting that shall include illuminating all required means of egress lighting, illuminated Exit Signs, Stairwell Lights, and all locations where emergency lighting must provide at least code required minimum illumination to allow easy and safe egress from the area involved.
- .4 WIRING FOR EMERGENCY SYSTEMS shall be in separate conduits. Specify that all emergency system junction boxes and covers shall be painted red.
- .4.1 Switches for emergency lighting circuits shall not be accessible to the public.
- .5 TRANSFER SWITCH: Transfer switch is a vital part of the proper operation of the system. In addition to current carrying abilities, transfer switch must be able to withstand voltage surges to meet reliability requirements. Special consideration over normal circuit devices or breakers should be given to transfer switch because of its application requirements. Its design must include normal duty, and fault current ratings of the switch. These play an important part of transfer switch application and protection scheme. It shall be capable of closing into high currents, of fault currents without damage, and withstanding severe duty cycle in switching normal-rated load. The design and operation of transfer switch must meet the requirements of this Standard and the following Codes and Standards: NSI/NFPA 70-1987(12) (National Electrical Code (NEC), NFPA 99-2002 and NEC 700-2005.
- .5.1 In addition to the two sources feeding the automatic transfer switch, provisions shall be provided so that equipment, on the load side of automatic transfer switch, can be locked-out-tagged-out.
  - .5.2 All new and existing buildings being provided with generators shall be provided with automatic transfer switches to separate emergency and standby systems.
  - .5.3 Existing buildings where emergency and standby systems are not on separate transfer switches shall provide new transfer switches to accommodate new emergency and/or standby loads being provided by the project.
- .6 EXISTING GENERATORS
- Commentary:*** Each existing generator will need to be looked at on a project by project basis. Many of the existing university generators are currently at rated load or over rated load. And will not be able to accommodate any new loads.
- .6.1 Existing capacities will need to be reviewed with the University to determine if the generator can serve any new loads.
  - .6.2 No new loads may be added to an existing generator without written permission from the University engineer or their designated person.
- 26 37 00. ELECTRICAL PROVISION FOR ELEVATORS
- .1 WIRING AND SWITCHING: Wiring shall be extended to fused switches located in elevator room.

## **DIVISION 26 – ELECTRICAL**

---

- .2 EMERGENCY CIRCUITS: An emergency circuit to mid point of the hoist way shall be provided for the elevator cab light, fan, and equipment room.
- .3 PIT INSTALLATIONS: Refer to Division 14. A light, light switch and GFCI convenience outlet must be provided in the pit of each elevator, each on separate circuits. If a sump pump is required for the elevator pit, then the sump pump will be provided with a dedicated circuit feed and not tied into the lighting or GFI circuit.

### **26 40 00. ELECTRICAL AND CATHODIC PROTECTION**

#### **26 41 00. FACILITY LIGHTNING PROTECTION:**

- .1 Each building shall be considered individually to determine the necessity for lightning protection. Lightning Risk Assessment calculations as noted in NFPA 780 Annex L shall be performed and submitted to the University through the project manager for review.

- .1.1 If it is deemed necessary to provide the lightning protection system for the facility, then the A/E shall design and specify an Underwriter's Laboratory Master Label System.

- .1.2 If it is decided that lightning protection is not necessary, this decision should be made a matter of record. A listing of the people consulted shall be included in the conference memos along with "RISK" calculations noted above..

- .2 GROUNDING SYSTEM REQUIREMENT: Because of possibility that a breakdown in grounding insulation may accidentally energize all plant or facilities, this Standard requires that ground connections shall be made to the electrode by methods providing the required permanence and ampacity, such as:

- .2.1 A permanently effective clamp, fitting, brace, or weld.

- .2.2 A bronze plug, which has been tightly screwed into the electrode.

- .2.3 All non-current carrying metallic structures or steel frame building are grounded.

The main purpose of grounding system is as follows:

- .1 To maintain low potential difference between metallic parts, ensuring freedom from electric shocks to personnel in the area.

- .2 To avoid fires from volatile materials and ignition in combustible atmospheres by providing an effective electric conductor system for the flow of ground fault currents and lightning (See Lightning Protection in Section 26 20 06.2.2.4 of the Standard). The connection between the grounding electrode and the earth should have a resistance less than 5 ohms.

- .3 All existing lightning protection system shall be maintained during building renovations and extended to any additions to the building.

- .4 Any new and existing systems will have UL Master Label "C".

- .5 Copy of UL Master Label C certificates shall be given to the University Engineer

- .6 Original certificate shall be framed and located next to fire alarm panel

- .7 Copies of certificate shall also be included in Operations and Maintenance Manuals.

#### **26 42 00. CATHODIC PROTECTION**

## DIVISION 26 – ELECTRICAL

---

- .1 UNDERGROUND PIPING: Refer to 22 70 30. (15490) for cathodic protection method when such protection is determined to be appropriate.

### 26 50 00. LIGHTING

- .1 LIGHT LEVELS-GENERAL: All new lighting installations at The University shall comply with the **Code for Energy Conservation in New Building Construction**. (Ohio Building Code, Article 27, O.A.C. 4101:2-27). Lighting requirements for the most common University building areas are set forth in this standard. The referenced light levels are understood to be a maintained light level. Light levels are measured at a 30-inch height from the floor or at the actual work surface, and represent the average level for the area or workstation. Circulation areas beyond workstations should be lighted to one-third the light level of the workstation, but in no case less than 20-foot candles.
  - .1.1 Specify that contractors shall fuse all indoor and outdoor lighting fixtures when installed.
  - .1.2 Utility Tunnels: Provide 2 foot-candles minimum with fixtures spaced 20' to 25' apart down the center of the tunnel on the ceiling. Provide vapor tight ceiling mounted fixtures using compact fluorescent lamps with appropriate globes and wire guard. Use fiberglass conduit with PVC boxes for tunnel lighting.

### 26 51 00. INTERIOR LIGHTING

- .1 RECOMMENDED FIXTURES: Fluorescent fixtures using 4 foot T8 tubes are generally preferred. Incandescent lighting may be used only with the written permission of the University Engineer. Any department requesting approval of incandescent lighting must be willing to accept financial responsibility for the maintenance of the incandescent lighting.

Where incandescent lamps are used as part of an equipment system or alarm, provide a minimum of 12 or 10% (whichever is greater) spare lamps of each wattage.

  - .1.1 The use of High Pressure Sodium (HPS) Lamps in fixtures for lighting large or open areas is recommended by this Standard in combination with metal-halide lamps for greater energy saving. Almost without exemption, the High Pressure Sodium (HPS) lamps shall be the choice for greatest economy and least use of energy, but the use shall be limited to warehouse large areas and high ceilings.
  - .1.2 Mercury vapor lights are not to be used. Exceptions, for research applications, must be submitted by the A/E for reviewed and approved by the University Engineer.

**Commentary:** *mercury vapor lamps are no longer in production.*
  - .1.3 METAL HALIDE lamps shall only be used in areas where there is assurance that they will be turned off at least once a week; this reduces the possibility of an explosion at end of life. Their use should be limited to areas in which network television coverage is expected, accurate color rendering is required, or gymnasiums.
  - .1.4 FLUORESCENT FIXTURES: All fixtures shall be independently supported from the structure above. Fixtures shall be all metal with hinged shielding louvers. Recessed fixtures with hinged frame open louvers may be used where required for architectural effect. Two hundred seventy-seven (277) volt fixtures shall be used where this voltage is available. Fixtures shall meet or exceed the requirements of the **Code for Energy Conservation in New Building Construction**.



## DIVISION 26 – ELECTRICAL

---

- .1.5 QUARTZ LAMP FIXTURES are not recommended; if used they must have lenses to protect against exploding lamps.
- .1.6 Ballasts: High Frequency Electronic type, specifically designed to use T8 lamps, instant start, to operate multiple lamps in a parallel configuration. Ballasts shall meet minimum performance standards as established by the Certified Ballast Manufacturers Association. Additional requirements shall include a maximum Total Harmonic Distortion of 20 percent, sound rating of "A", shall comply with applicable standards as set by ETL, F.C.C., NEC, I.E.E.E., be listed by UL and carry a five year replacement warranty. Separate ballasts should be provided for each lighting fixture; exception, tandem or cross ballasting of adjacent fixtures is permitted provided the fixtures are directly connected to each other.
- .1.7 Ballasts for compact fluorescent lamps shall be electronic type, and shall have the following characteristics:
  - A. Ballasts to be high Power Factor type.
  - B. Ballasts factor shall be .95 or greater.
  - C. Ballasts for multiple lamps shall be parallel wiring type.
  - D. Minimum starting temperature shall be 50 Degrees F.
  - E. Fixtures with multiple ballasts shall have individual fusing for each ballast.
  - F. Total harmonic distortion shall be less than 20%.
  - G. Ballast shall contain end of lamp life fault mode shutdown protection
- .1.8 LED (Light Emitting Diode) fixtures may be considered for illuminating interior spaces. Provide spare parts for each type LED fixture
  - .1.8.1 If dimming of LED fixtures is desired, it will be the responsibility of the A/E to specify the correct dimmers and provide the correct wiring diagrams as part of the contract documents..
  - .1.8.2 Workable sample fixtures and dimmers will be provided during the design phase and with the shop drawing submittal for review and comment. These fixtures will become attic stock.
- .2 Line Fuses: A line fuse shall be included in the fixture for each ballast in addition to the internal protection of the class "P" ballasts. Line fuses shall be appropriate for the application and wired in place by the fixture's manufacturer. Fusing for fluorescent lighting fixtures shall be non-time delay type similar to Bussmann type GLR with HLR holders.
- .3 Lenses shall not be specified as an alternative for louvers. If lenses are required for the project, the project shall be engineered for these units. Tempered lenses shall be specified on quartz lamp fixtures.
- .4 Fluorescent Lamps: Four (4) foot 32 watt and two (2) foot, 17 watt, T8, instant start lamps with color temperature of 3500K and minimum of CRI of 74.
- .5 Specify the use of exit signs utilizing Light Emitting Diodes (LED) light source with life expectancy greater than (10) ten years.
- .6 INCANDESCENT LAMPS: When approved by the University, specify the 130-volt, inside frosted lamp for general application.
- .7 LIGHTING SAFETY: Stairwells in buildings shall have sufficient fixtures so that the loss of one lamp or ballast will not leave the area dark. The mounting of the fixtures shall not be at the extreme height but must be accessible for maintenance. Position fixtures only on

## DIVISION 26 – ELECTRICAL

---

walls over landings at a minimum height of seven (7) feet to the bottom of the fixtures and a maximum height of eight (8) feet to the top of the fixtures. Fixtures shall have lenses; no bare lamps shall be permitted. Lighting in stairwells shall not be manually switched.

- .8 Provide the following spare parts with the listed quantities for compact and/or T5 fluorescent fixtures for each item and size required:
- A. Fuses – 10%, minimum of 15 per amp rating
  - B. Fuse Holders – 10%, minimum of 5 per each type
  - C. Ballasts – 5%, minimum of 3 of each type
  - D. Lamp Sockets – 10%, minimum of 10 of each lamp type
  - E. Fixture Lenses – 10%, minimum of 2 of each lens type

- .9 All submittal reviews for Compact and/or T5 Fluorescent fixtures shall include the following:

- A. Catalog cut sheets.
- B. Lists of spare parts with quantities to be furnished.
- C. Samples of fixtures along with a sample of each spare part to be supplied.

Turn spare parts over to the university area shop supervisor and obtain signed receipt.

A copy of each approved submittal and a copy of each signed receipt shall be included in the Operation and Maintenance Manuals.

- .10 Spare lamps should be provided as follows:

Lamp Type	Quantity Installed	# of Spares
H.I.D.	1-10	1
	11-20	6
	21 or more	12
Fluorescent	1-10	1
	11-20	6
	21-50	12
	51-200	36
	201 or more	72

Quantity of lamps installed and not fixtures should be calculated for each lamp type and wattage.

- .10.1 Determine the number of spare incandescent lamps of each wattage and voltage for the project with University project manager and operations representative.

- .11 Incandescent lighting is permitted in dedicated Telephone Equipment Rooms.

## DIVISION 26 – ELECTRICAL

---

- .12 Fixture whips shall be made up of either #12 conductors in ½" flexible conduit minimum or #12 type MC Cable minimum.
  - .1 MC cable shall be provided with green grounding conductor.
  - .2 If cable ties are used for support then they must be UV stable cable ties.
  - .3 Fixture whips below ceilings may be provided with as cords similar to type "ST" rated 600 volts provided the following are met.
    - .3.1 Limit one cord per fixture.
    - .3.2 Do not daisy chain fixture cords for exposed fixtures.
    - .3.3 ST cord shall be provided with green grounding conductor
    - .3.4 Cord shall not be extended above ceiling other than into outlet boxes
    - .3.5 Cords are made up of #14 conductors minimum
    - .3.6 Cords longer than six feet are properly supported
    - .3.7 If cable ties are used for support then they must be UV stable.
  - .4 SO Type cord may be used exposed below open structures for HID fixtures only if they are provided with an appropriate cord cap.
- 26 56 00. EXTERIOR LIGHTING
  - .1 LIGHTING FOR THE ENTIRE SITE, INCLUDING DRIVEWAYS, WALKS, PARKING AREAS, and THE BUILDING PERIMETER shall be included in the contract documents.
  - .2 FIXTURES: High Intensity Discharge (metal halide) fixtures mounted on the building or on suitable standards are required for all exterior site lighting east of the Olentangy River. Exterior lighting west of the Olentangy River shall be high pressure sodium. These fixtures shall be automatically controlled by photocell(s) for a "dusk on dawn off" operation. More details about exterior lighting or lighting poles may be obtained from OSU Facilities Operations and Development website at <https://fod.osu.edu/resources>, click on "Design" tab in Vendor Resources.
    - 2.1 LED fixtures may be considered as a lamp source for exterior lighting. Additionally the project will be required to provide the university with spare parts for light fixtures and poles. Quantity of spare parts will be determined on a project by project basis.
    - .2.2 Light Control shall be provided on all exterior lighting fixtures. The fixture shall be insect proof. Vandal proof fixtures shall be used if the fixtures are mounted 10 feet or less off the ground.
  - .3 FIXTURE LOCATION: Fixtures shall be located in such a manner that dark voids and excessive glare in windows are eliminated. Accessibility for servicing must be considered in locating fixtures. Consideration must also be given to light spillage onto adjacent facilities (existing or planned) such as greenhouses, which are light sensitive. Use directional or shielded lighting as necessary. Check with the University Engineer for the type of lights. Grounding rods shall be installed in all lighting poles.
  - .4 Outdoor Lighting Levels shall be designed as follows:
    - .4.1 Primary Walkways and problem areas - 2 foot-candles (FC) average and .5 FC minimum.

## DIVISION 26 – ELECTRICAL

---

- .4.2 Secondary Walkways and other areas - 1 FC and .25 FC minimum.
- .4.3 Primary Streets - 2 FC average and .25 FC minimum.
- .4.4 Parking Lots - 1 FC average and .25 FC minimum.
- .4.5 High Activity outdoor parking (i.e. St. John Arena) 2.4 FC average and .6 FC minimum.
- .5 Design outdoor lighting to be fed from 100-amp switch, which in turn feeds 100 amp contactor with coil controlled by a photocell. Lighting contactor shall be provided with "hand-off-auto switch. Use twist lock type photo controls to control contactors.
  - .5.1 Load side of lighting contactor will be provided with a fusible 100 amp disconnect switch to help with serving of lighting.
- .6 Run all three phase legs and neutrals to lighting standards and fuse each pole individually. Alternate each pole to different phase legs and balance phases. Conductors used for outdoor lighting shall be full color insulation for the designated voltage.

**Commentary:** *Do not use black conductors with color tape.*
- .7 Taps inside poles shall be insulated and molded for precise fit. Connectors with removable access plugs over hex screws.. These connectors shall not require cover and taping. Connectors shall be abrasion and chemical resistant and also be UV rated. Connectors shall be rated for 600 volts, 90 degrees C.

**Commentary:** *Split bolt connectors are not acceptable.*
- .8 The University has no secure storage. Any existing poles, luminaires, concrete collars or screw-in bases removed for relocation at a later date must be stored off campus at the project's expense or in the project's staging area. Luminaires shall be removed prior to pole removal and stored indoors. Any items, except for luminaires, being turned over to the University shall go to the University designated storage location. Luminaires shall be taken to the M/E shop at 2560 Kenny Road.
- .9 All exterior lighting poles shall be provided with color coded tag as noted on the University website. Tags will identify pole number, power source and circuit number and will be color coded to distinguish phase of power source.
- .10 Outdoor lighting shall be fed with full color conductors.
- .11 When installing the Gullwing poles, provide Quazite box adjacent to pole and provide #10 wire from feed into pole base. Fusing shall be accessible from pole base.
- .12 Any conductors removed for outdoor lighting and not being reused shall be taken to the M/E shop at 2560 Kenny Road.

### 26 58 00. LIGHTING CONTROL

- .1 **MULTIPLE SWITCHING:** The use of multiple switching shall be evaluated for each space and condition. Where possible, switching shall be circuited to effectively use artificial (natural?) lighting from windows; to permit light reduction during partial occupancy; and to permit reduced lighting for custodial activity.

OCCUPANCY SENSORS shall not be used as the sole means of switching. Manual switches will be provided in all areas with occupancy sensors. Occupancy sensors shall not be used

## DIVISION 26 – ELECTRICAL

---

in mechanical rooms or rest rooms. At installation, set all sensors to maximum sensitivity and maximum time delay.

- .2 REMOTE SWITCHING by means of a central control should be evaluated for new construction and for large renovation projects.

- .3 DIMMING CONTROL: Where dimming is required it shall be used to control incandescent lighting and may be used for Hi-Lume **and approved** solid state dimming ballast fluorescent fixtures for low lighting levels. The control panel/panels required for the dimming system shall have the U.L. label. Each dimming module shall be U.L. tested and tested specifically for the type of load it is controlling. Each dimmer module shall possess a means of easily disconnecting power on an individual module-by-module basis.

Dimming panels shall be cooled without the use of cooling fans with no exception, and shall be capable of operating as such in an environment of 0 degree to 40 degree centigrade. Satisfactory independent laboratory test results shall be required, that at +40 degree centigrade and at full load, the maximum temperatures of both filter chokes and SCRs/Triacs are not exceeded.

There shall be one **air-gap** positive off relay for dimmer, either integral to the dimmer or mounted elsewhere in the same panel. Other advanced technological approaches that give the same or better operational result is highly recommended by this Standard.

All controls shall have the capabilities of reverting back to their previous status after any duration of power outage (power failure memory), without the use of any type of rechargeable or trickle-charge type of battery.

LUTRON DIMMING SYSTEMS with **ten years warranty** meet University standards. Other systems must be submitted to the University Engineer for approval.

- .3.1 SPECIAL REQUIREMENTS FOR FLUORESCENT DIMMING SYSTEMS: Before specifying fluorescent dimming systems, the A/E shall consider the following:

.3.1.1 100 hour "burn-in" time is required for the fluorescent lamps when using the dimming ballasts.

.3.1.2 the cost of replacing the ballast and lamps when needed is 200-300% more than replacing Standard Systems.

Therefore, this Standard requires the A/E to review the application of dimming devices and submit recommendations to Facilities Design and Construction before incorporating into specifications.

- .4 PARKING RAMP INTERIOR LIGHTING shall be circuited to permit lighting of dark interior areas during the day without lighting those areas which receive sufficient natural light. Automatic control of ramp lighting by photocell is required.

- .5 ALL EXTERIOR AREA AND SECURITY LIGHTING shall be "dusk on and dawn off", powered from one location in the building, and controlled from the photo control, with provisions for manual override. Time clock control shall **not** be used on exterior or security lighting.

### 26 60 00 EMERGENCY PHONES

- .1 A/E to specify emergency phones as directed by the OSU Project manager and the university Department of Public Safety. (See appendix Y for additional information)

## DIVISION 26 – ELECTRICAL

---

- .2 Emergency phones will be provided with power and a communications line from the nearest building. Specify contractor to provide two different conduits (See appendix M for additional information)
- .3 Both conduits may be PVC Schedule 40 rated for direct burry underground. Conduits inside the building are to be Galvanized Rigid Steel (GAR).
  - .3.1 A/E shall specify Contractor to provide manufacturer's recommended cement for PVC conduit.
- .4 Power for emergency phones shall be 120 volt AC fed from a dedicated 20 amp/1 pole circuit breaker. Provide circuit breaker with lock-on device.
  - .4.1 If the building has a generator then A/E shall specify to connect emergency phone to a dedicated emergency circuit breaker.
- .5 Emergency phones shall be manufactured by Gai-tronics and made up with the following components:
  - .5.1 Stanchion shall be Gai-tronics model 234-030 (**Note: this stanchion is OSU Specific**)
  - .5.2 Emergency Phone shall be Gai-tronics Model 397-001 single button flush mounted.
  - .5.3 Strobe light at the top shall be Gai-tronics model 530-001 120 Volts A.C. with LED strobe lamp. Strobe to have a NEMA 3R weatherproof rating, UL listing and an approximate 10 year lamp.
- .6 Any existing emergency phones being relocated shall meet the requirements of paragraphs .1, .2, .3 and .4 above.
- .7 Mount emergency phones on either a screw-in base or concrete base. See the following website for details:
  - .7.1 <https://fod.osu.edu/resources> , click on "Design" tab in Vendor Resources
- .8 Refer to Division 27 Section 273205 and Appendix M for additional information

END OF DIVISION 26 - ELECTRICAL

## **DIVISION 27 – COMMUNICATIONS**

2006 Edition, Published January 1, 2006; Division Revision Date: August 1, 2012

### **27 00 00. COMMUNICATIONS**

#### **27 05 28 Conduits**

- .1 Conduits: Minimum size to be provided is 1". Conduits for communications shall be galvanized rigid steel conduit or surface mounted raceway (Wiremold) when exposed below 8' above finish floor.
  - .1.1 Conduits run above 8' above finish floor may be EMT up to 4" with compression fittings.
  - .1.2 OSP (Outside Plant) cable shall be run in galvanized rigid steel conduit when transitioning from the outside of the building to the Main Distribution Frame (MDF).

### **27 30 00. VOICE COMMUNICATIONS**

#### **27 32 05. TELEPHONES**

- .1 TELEPHONES: Consult the Program of Requirements for spaces in which telephones are required. Possible inclusion of other spaces should be discussed at the initial planning conference. Also see Communications Wiring Standard in Appendix.
  - .1.1 PROVISIONS FOR TELEPHONE INSTALLATION: Consult the University Architect regarding the source of details for design of conduit raceway systems, telephone equipment rooms, telephone switchgear or switchboard, equipment room ventilation or cooling, and other requirements peculiar to the project. Conform with all stipulated requirements.
  - .1.2 LIGHTING: For Campus Emergency Phones: See Appendix M, Communication Wiring Standards.

### **27 40 00. AUDIO-VIDEO COMMUNICATIONS**

#### **27 41 00. AUDIO-VIDEO SYSTEMS**

- .1 TEACHING SYSTEMS: Provide closed circuit TV and other teaching aids as required by the Program of Requirements.

### **27 50 00. DISTRIBUTED COMMUNICATIONS AND MONITORING SYSTEMS**

#### **27 51 23. INTERCOMMUNICATION AND PROGRAM SYSTEMS**

- .1 INTERCOMMUNICATIONS SYSTEMS: See Appendix M, Communications Wiring Standard.

## **DIVISION 27 – COMMUNICATIONS**

---

- .2 OTHER INTERCOMMUNICATIONS SYSTEMS: Refer to the Program of Requirements
  - .2.1 LOCAL SYSTEMS: Local PA systems shall be capable of operation without a technician in attendance.
  - .2.2 STORAGE OF EQUIPMENT: Design adequate spaces, properly secured, for storage of portable equipment.
  
- 27 52 23. NURSES CALL SYSTEMS: Refer to the Program of Requirements.
  
- 27 53 13. CLOCK AND PROGRAM SYSTEMS:
  - .1 SUPERVISED SYSTEM: A supervised clock system will be provided only when so required by the building program. Supervised clocks shall be impulse type only, connected to the University clock system. Clock second hands are not acceptable.
  - .2 CLOCK AND FIRE ALARM SYSTEMS BIDDING PROCESS: Fire Alarm systems and Supervised systems are viewed by the University as separate stand-alone systems. They shall not be bid as a combined system by a single manufacturer. Each system shall be bid with a separate cost proposal in projects with Fire Alarm and Supervised Clock systems.
  
- 27 53 15. CLASS BELLS: Provide in corridors of all academic buildings. Bells shall be 10-inch under-dome, single stroke, 110-volt a-c, with power obtained from local building supply, and pilot wire control from the campus system. Installation height shall be specified as 80" above the finished floor. It is expressly prohibited to make any additions to the Monitor Dynamics Incorporated (MDI) system.

---

END OF DIVISION 27 - COMMUNICATIONS



**28 00 00. ELECTRONIC SAFETY AND SECURITY**

**28 10 00. ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION**

28 10 05. SECURITY SYSTEM for Security and/or CCTV: The following situations, but not limited to, for installing security and/or CCTV may be required by OSU Department of Public Safety (DPS):

- Building perimeter security and access control
- High monetary value property owned by or loaned to The Ohio State University (OSU)
- Property with significant historical, cultural or artistic value
- Intellectual Property storage
- Where dictated by law or regulations
- Where currency is counted or exchanged (these areas shall include CCTV into the security plan)
- Any areas where external threats are perceived to be likely (Duress alarms must include CCTV into the security plan)

Security systems shall be installed and connected to the campus-wide Access Control and Alarm Monitoring System (ACAMS), which provides alarm signal to the Department of Public Safety (DPS) Communication & Security Technology Division. -Requirements for area security systems must be discussed at the initial planning conference with the DPS. - Reference Appendix Y for the basic security planning design requirements. All security plans shall be reviewed and approved by DPS and Facilities Operations and Development's (FOD's) Lock & Key Services (LKS).

28 10 10. ACCESS CONTROL and ALARM MONITORING SYSTEM (ACAMS): The system shall be based upon, and connected to, the University's existing campus-wide Access Control and Alarm Monitoring System (ACAMS) The system is applicable to all Columbus campus buildings, excluding the University Hospitals and regional campuses. All Columbus campus buildings shall require 24 hour remote monitoring and reporting, and shall use this ACAMS system, and shall report to DPS Communications & Security Technology Division Central Alarm Center and the Facilities Operations and Development Service Center. The ACAMS system is not supported on the regional campuses. Other requirements for security systems at the regional campuses shall be determined in coordination with DPS.

.1 MINIMUM REQUIRED INFRASTRUCTURE for LIFE SAFETY: Whether or not there is any access control specified or not, provide the initial basis of an Access Control and Alarm Monitoring Systems (ACAMS). Specify and provide as a minimum all of the following infrastructure for Life Safety, including:

- .1.1 Minimum (1) Lenel Intelligent System Controller with a 3300 board, including the following:
  - .1.1.1 Host communications on path #1, TCP/IP.
  - .1.1.2 Host communications on path #2, voice grade dial-up using Securcomm Uniflex DC336 modem.
  - .1.1.3 Communication jacks within the controller for path #1 and path #2.
- .1.2 Quantity as required Lenel Input Control Module(s) using an 1100 board.
- .1.3 Lenel manufacturer's battery backups for the above.
- .1.4 NetShelter, to house the following:
  - .1.4.1 Office of the Chief Information Officer (OCIO) primary fiber-to-wire media converter.
  - .1.4.2 OCIO primary Ethernet switch.
  - 
  - .1.4.3 Door Tamper switches, front & rear, report to Lenel.
  - .1.4.4 Dedicated 20A/120V power and duplex outlet to serve the OCIO's primary Ethernet switch. Note: do not tie into existing circuits.
  - .1.4.5 Door locking device shall be equipped with approved cylinders and interchangeable core per Division 08 of these standards.
- .1.5 Fire Alarm System auxiliary points to be monitored shall include:
  - .1.5.1 Fire Alarm (Detection) System Common Alarm

- .1.5.2 Fire Alarm (Detection) System Common Trouble Signal
  - .1.5.3 Fire Alarm (Detection) System Common Supervisory Signal
  - .1.5.4 Fire Suppression System Common Alarm
  - .1.5.5 Fire Suppression System Common Trouble Signal
  - .1.5.6 Fire Suppression System Common Supervisory
  - .1.6 HVAC system auxiliary points to be monitored shall include:
    - .1.6.1 HVAC System Common Loss of Heat Alarm.
    - .1.6.2 HVAC System Common Loss of Cooling Alarm.
    - .1.6.3 HVAC Loss of Critical Environments Alarm (if any critical environments apply).
  - .1.7 Emergency Generator auxiliary points to be monitored shall include:
    - .1.7.1 Emergency Generator Is Running Alarm.
  - .1.8 This minimum infrastructure must be specified to be consistent with all of the requirements of the below Standards, paragraphs .2 through .11, inclusive.
- .2 FIELD HARDWARE: The new field hardware shall be manufactured by Lenel Systems, International, Inc., Corporate Headquarters, 1212 Pittsford-Victor Rd., Pittsford, NY 14534-3820, and shall include:
- .2.1 Quantity 1 or more, Intelligent System Controller(s) (ISC's), LNL-3300 board using a LNL600-ULX enclosure , minimum one per building, and/or additional one per individual business group if necessary to segregate different costs or different application requirements within any single building. Do not share ISC's between buildings. The primary Intelligent System Controller (ISC) must be mounted within the Main Distribution Frame (MDF) room.  
The lock for the 600 shall be purchased by the contractor through the Facilities Operations and Development's Lock & Key Services, and shall be field installed by the Facilities Operations and Development's Lock & Key Services. Approved lock cylinders and cores shall be per Division – 08 of these standards, part number Best 5E7D1 series Cam Lock, and appurtenances.
    - .2.1.1 Host Dual Path communication shall be included and enabled:
      - A. Host Communication Path #1 shall be TCP/IP communications using Ethernet over the campus-wide OCIO (fiber-based) data communications network, 10/100 BaseT Connecting to the micro serial device in the main Lenel panel.
      - B. Host Communication Path #2 shall be Dial-up (modem) communications over the campus-wide OCIO (copper wire based) voice communications network.
      - C. Within each Intelligent System Controller, provide data jacks for connection of the communications network wiring.
  - .2.2 Quantity as required, Input Control Modules (ICM's), Output Control Modules (OCM's), Dual Reader Interface modules (DRI's), Magnetic-swipe Access Readers, Keypads, and/or Proximity Access Readers. Single Reader Interface modules (SRI's) are prohibited.
  - .2.3 Provide lithium battery for backup of local event memory and local databases.
  - .2.4 Provide 12-VDC lead-acid battery for 4-hour backup for local controller and local module operation.
  - .2.5 Door hardware operation shall remain exclusively on commercial power, and shall 'not' be battery backed-up. Door hardware shall be configured to close and lock upon loss of commercial power, unless rated as a fire door, which will then be required to latch but remain unlocked upon loss of commercial power. Refer to and coordinate with, Division 8, Doors and Windows, Section 08 70 00 - Hardware, of these Building Design Standards plus the Facilities Operations and Development's Lock & Key Services concerning door hardware and access control.
- .3 HOST-COMPUTER SOFTWARE and FIELD FIRMWARE AND FLASHWARE: The existing system host-computer software is Lenel OnGuard® Access™ manufactured by Lenel Systems, International, Inc., Corporate Headquarters, 1212 Pittsford-Victor Rd., Pittsford, NY 14534-3820. Furnish all firmware and flashware

## DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

---

within new field hardware to be compatible with existing host computer software revisions as currently installed within the existing host-computer.

- .4 ADDITIONAL EQUIPMENT: Provide additional equipment within the communications Main Distribution Frame (MDF) room, as follows:
  - .4.1 NET-SHELTER ENCLOSURE: Provide a wall-mounted rack NetShelter enclosure, with adjustable front vertical mounting rail, adjustable mounting depth, glass front door, front and back doors open 180 degrees, double-hinged design on each door, integrated cable access holes, lockable doors, multi-purpose mounting rails, powder coat black paint finish, and ventilated. Enclosure shall be equivalent to American Power Conversion Corp. (APC) NetShelter WX Wall-Mount Enclosure 13U Glass Door, Black, APC part number AR100. Enclosure shall include and house the following hardware:
    - .4.1.1 OCIO FIBER-to-WIRE MEDIA CONVERTER: For connection to OCIO fiber data communications network, 10/100 BaseT (specific media converter to be provided by OCIO).
    - .4.1.2 OCIO PRIMARY ETHERNET SWITCH: For connection to OCIO data communications network, 10/100 BaseT, rack mount, (specific switch to be provided by OCIO).
    - .4.1.3 Provide door tamper switches on front & rear doors, and report as an alarm to the Lenel system.
    - .4.1.4 Provide a dedicated, 20A-120vac circuit breaker, wiring shall be in conduit, with duplex outlet within the NetShelter enclosure. The power shall be dedicated to the devices housed in the net shelter exclusively. Provide/install a circuit breaker lockout.
    - .4.1.5 The door locks for the NetShelter shall be purchased by the contractor through Facilities Operations and Development's Lock & Key Services, and shall be field installed by Facilities Operations and Development's Lock & Key Services. Approved lock cylinders and cores shall be per Division- 08 of these standards, part number Best 5E7M1 series Cam Lock, and appurtenances.
    - .4.1.6 The NetShelter Enclosure must be mounted within the Main Distribution Frame (MDF) room with the approval of its location from OCIO.
- .5 LENEL AUTHORIZED VAR: The system shall be furnished and installed by a contractor that is certified by Lenel as an Authorized OnGuard® Value Added Reseller (VAR) of Lenel systems, for sales, installation, and service for the Columbus, Ohio area at the time of award of the subcontract for the system. All warranty service shall be by this same contractor.
- .6 CARD READERS and CARDS: University standard card readers and cards are magnetic-swipe, using BUCK-ID card or University Hospital ID card, all using Wiegand communications protocol. Proximity readers, which are more expensive to purchase and maintain versus magnetic-swipe readers, shall be used only with the approval of Facilities Operations and Development's Lock & Key Services and for specific operational and/or safety requirements only. Cards for proximity readers, which are more expensive to purchase and maintain versus magnetic-swipe cards, are separately available for premium charge through University BUCK-ID Services. Costs for proximity cards shall remain the responsibility of the Using group.
  - .6.1 Required to use LNL 1320 dual reader interface
  - .6.2 MAGNETIC-SWIPE CARD READERS: Lenel LNL2010W.
  - .6.3 MAG-SWIPE CARD READERS with KEYPAD: Lenel LNL2020W.
  - .6.4 KEYPAD, only: Lenel LNL834S121NN, LNL826S121NN or LNL-CK with a LNL2010W
  - .6.5 All keypad installations will require LED indicator panel part number RP9 display with red and green indicators and a local sounder.
  - .6.6 PROXIMITY READERS: Proximity readers shall be used only with the approval of Facilities Operations and Development' Lock & Key Services and for specific operational and/or safety requirements only.
    - .6.6.1 PROXIMITY READER: HID Corporation, ProxPro II #5455B (N-00\_04).

## DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

---

- .6.6.2 PROX READER with KEYPAD: HID Corporation, ProxPro #5355A (K-00\_09).
- .6.6.3 HID Corporation (An ASSA ABLOY Group company),  
9292 Jeronimo Road, Irvine, CA 92618-1905, USA,  
Phone: 949 598 1600 or 800-237 PROX, Fax: 949 598 1690
  
- .7 MONITORING CONTACTS: Door monitoring contacts, and wiring and conduits thereto, shall be concealed and invisible when the door is closed. Externally applied door monitoring contacts, externally applied conduit or Wiremold, and wire without conduit are prohibited.
  
- .8 AUXILIARY POINTS to be MONITORED/ALARMED: Provide monitoring and alarming of the following minimum auxiliary points, including:
  - .8.1 ACAMS system auxiliary points to be monitored:
    - .8.1.1 Door Tamper Switches from any-and-all enclosures for ACAMS controllers, ACAMS modules, and the NetShelter enclosure.
    - .8.1.2 Power Failure Status, for Commercial 120-VAC power, from any-and-all power supplies for ACAMS controllers and ACAMS modules.
    - .8.1.3 Power Failure Status or Low-Battery Status, for 12-VDC, Lead-acid Battery Backup, from any-and-all power supplies for ACAMS controllers, and ACAMS modules.
  
  - .8.2 Fire Alarm system auxiliary points to be monitored:
    - .8.2.1 Fire Alarm (Detection) System Common Alarm
    - .8.2.2 Fire Alarm (Detection) System Common Trouble Signal
    - .8.2.3 Fire Alarm (Detection) System Common Supervisory Signal
    - .8.2.4 Fire Suppression System Common Alarm
    - .8.2.5 Fire Suppression System Common Trouble Signal
    - .8.2.6 Fire Suppression System Common Supervisory
  
  - .8.3 Building Automation System auxiliary points to be monitored:
    - .8.3.1 HVAC system Common Loss-of-Heat Alarm.
    - .8.3.2 HVAC system Common Loss-of-Cooling Alarm.
    - .8.3.3 HVAC system Common Loss-of-Critical-Environments Alarm (if any critical environments apply).
  
  - .8.4 Emergency Generator points to be monitored: It is important to never exceed 500-hours run time on any emergency generator within any 12-month period, to minimize operating hours, maximize generator life, and to avoid additional EPA permits for the generator.
    - .8.4.1 Emergency Generator Is Running Alarm. Provide a remote annunciator panel, required by NFPA 110-5.6.6 Remote Controls and Alarms, located next to the fire alarm system's remote annunciator panel as approved by the Division of Emergency Management & Fire Prevention.
  
- .9 CABLE AND WIRE:
  - .9.1 All fiber optic cable shall be specified and provided consistent with all requirements of Appendix M, The Ohio State University Communications Wiring Standard.
  - .9.2 All TCP/IP communications wire and all Dial-up communications wire shall be specified and provided consistent with all requirements of Appendix M, The Ohio State University Communications Wiring Standard, 'and' consistent with all requirements of the manufacturers.
  - .9.3 All communications wiring between the Intelligent System Controller and all downstream modules, shall be specified and provided consistent with all requirements of all sections of Division

## DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

---

26 and 27 specifications, 'and' consistent with all requirements of the manufacturers. All communications on the ACAMS system using RS-485 communications protocol must use 2-pair twisted/shielded wiring, Belden #9842 or Belden equivalent.

- .9.3.1 Belden #9842, or Belden equivalent
- .9.3.2 Numbers of pairs - 2.
- .9.3.3 Total numbers of conductors - 4.
- .9.3.4 AWG - 24.
- .9.3.5 Outer Jacket PVC - polyvinyl chloride.
- .9.3.6 NEC/UL specification CM, NON-plenum.
- .9.3.7 Outside diameter, .340 inches.
- .9.3.8 (24 AWG stranded (7x32) tinned copper conductors, twisted pairs, polyethylene insulated, overall 100% Beldfoil® shield plus a 90% tinned copper braid shield, 24 AWG (7x32) tinned copper drain wire, PVC jacket.)

.9.4 All power wiring, and all control wiring to-and-from controllers, modules, readers, powered latches, etc., shall be specified to be in conduit and shall be provided consistent with all requirements of all sections of Division 26 specifications, 'and' consistent with all requirements of the manufacturers.

.10 EXCEPTIONS: Temporary independent security systems outside the University ACAMS system require approval from DPS and FOD's LKS to meet the following requirements: -

.10.1 Call-in alarms from Remote Central Station providers within OSU Police primary jurisdiction shall identify OSU DPS as their primary point of contact for all incoming alarms: fire, intrusion, duress, etc. -

.10.1.1 Approval excludes service or maintenance calls for independent security systems.

.10.2 Alarm Subscribers / Remote Central Station providers shall annually submit an up-to-date copy of the "OSU DPS Alarm Registration" form to OSU DPS. The form can be found on the Department of Public Safety's website <https://dps.osu.edu> -or by calling 614-292-2121.

.11 PROHIBITIONS:

.11.1 Single Reader Interface modules (SRI's) are prohibited.

.11.2 Externally applied door monitoring contacts, externally applied conduit or Wiremold, and wire without conduit are prohibited.

.11.3 Splicing of power and control wiring and cables and the use of wire nuts are prohibited.

*Commentary: Splicing of wire and cables and the use of wire nuts often cause ground faults and are difficult to trace.*

### 28 23 23 VIDEO SURVEILLANCE SYSTEMS / CLOSED CIRCUIT TV (CCTV)

.1 The system shall be based upon, and connected to, the University's existing campus-wide video surveillance system.

.1.1 All security equipment shall be reviewed for system compatibility by DPS and in consultation with the project team.

.1.2 All security equipment shall report all signals to DPS. Any signal sent out beyond DPS will be monitored and approved by DPS.

- .1.3 Locations of security cameras indicated in the project documents are schematic only, final field locations of security cameras shall be approved by DPS prior to installation.

**Commentary:** *Final security camera locations are to be functional. Coordinate with other trades to avoid conflict with, but not limited to, light fixtures (obstructions and glare), exposed ductwork, architectural clouds, and FFE, etc.*

**28 30 00. ELECTRONIC DETECTION AND ALARM**

**28 31 00. FIRE DETECTION AND ALARM**

- .1 GENERAL: Design the fire detection and alarm system to minimize risk to the University's Customers (students, patients, residents, researchers, staff, and visitors), minimize risk to the University's property, reduce the University's support costs, and allow for cost-effective future expansion by the University. Design a complete system including:

Control panels,  
Annunciators,

**Initiating devices:**

Manual pull-stations,  
Automatic smoke detectors,  
Automatic heat detectors,  
Automatic rate-of-rise detectors,  
Automatic flow and tamper switches, and  
Other initiating devices (dry contacts, etc.) as required

**Notification appliances:**

Horns: Horns shall be allowed only with existing horn systems when the renovation project is limited in scope. The use of horns requires early project review for approval by Facilities Operations and Development's Technical Services Group and Division of Emergency Management and Fire Prevention;

Speakers,

Strobes,

Other notification appliances (dry contacts, etc.) as required;

Other device types:

Electromagnetic Fire & Smoke Barrier Door Holder releases,

Fire Exit/Security Egress Doors with Electrically Locking /Unlocking Door Hardware provide Fire Alarm Input. The building's fire alarm system shall provide normally closed contacts which open on alarm.

**Commentary:** *The input disables the electrical locking device (fail safe) upon a fire alarm.*

Fan Shutdown Relays, and any other items as required for a complete system.

- .1.1 SINGLE SYSTEM FUNCTIONS: Within any single building, design a complete system that integrates the existing and new systems into a single Fire Alarm Control Panel (FACP) system at one common location. For systems that are to be integrated with existing systems request the University Project Manager confirm with Facilities Operations and Development's Fire System Shop that the existing system is operating normally, prior to and following construction. Integrate and update to current technology the following into one system:

Existing common alarms from existing systems,

New common alarms from new systems,

Existing common trouble signals from existing systems,

New common trouble signals from new systems (all trouble and alarm resets are to be located at one point),  
Single-button building system, common alarm silence, silences existing and new systems in parallel, and  
Single-button building system, common reset, resets existing, and new systems in parallel.  
All panels shall be by the same manufacturer.

The A/E shall review with Facilities Operations and Development's Technical Services Group the acceptable Fire Alarm System manufacturers for a project.

**Commentary:** *-Examples of acceptable basis of design fire alarm system manufacturers: OSU Wexner Medical Center: SimplexGrinnell 4100ES; Student Life Residence Halls: Siemens Fire Finder XLSV; Academic and Facility Operations & Development buildings: Notifier ONYX Series NFS2-640.*

*The installation of voice fire alarm systems on all campuses is intended to enhance the Department of Public Safety's ability to communicate in an emergency.*

- .1.2 COMPLIANCE: All new systems shall be Underwriters' Laboratory (UL) listed as compliant with National Fire Protection Association (NFPA) Standards 72 A, B, C, D, and E, most current edition, and shall be installed in accordance with the Ohio Building Code (OBC) and the Ohio Fire Code (OFC). Initiating devices for ventilation systems shall be installed in compliance with NFPA Standard 90A. Initiating devices for water flow shall comply with NFPA 13 (Sprinkler Systems) and NFPA 101 (Life Safety Code) and other appropriate or pertinent NFPA Standards regarding the installation, locations, and sensitivity of flow alarms and annunciation. Each piece of equipment shall be approved, listed, and labeled with the UL label.
- .1.2.1 Transient Voltage Surge Suppression (TVSS) shall be specified for all new fire alarm systems and existing systems that do not have TVSS installed. Verify that adding TVSS to existing fire alarm control panels will not void the UL Listing.
- .1.3 The following requirements take precedence over the requirements in NFPA 72 and the OBC:
- A. All fire alarm systems shall also be capable of functioning as an emergency communication system (ECS).
  - B. The emergency communication system (ECS) must provide an automatic voice message in response to the receipt of a signal indicative of a fire emergency. The Fire Alarm Voice Evacuation Standard Message shall be: (Pre-alarm tone Slow Whoop) ---- "May I have your attention please, a fire alarm has been reported in the building please exit the building by the nearest exit or stairwell, do not use the elevator."
  - C. Manual control with the capability of making live voice announcements must also be furnished to provide occupants notification on either a selective or all-call basis.
  - D. With the exception of mass notification, a fire alarm and emergency communication system are not permitted to be integrated with other building systems such as building automation, energy management, security, and so on. Fire Alarm and emergency communication systems must be self-contained, standalone systems able to function independently of other building systems.

## DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

---

- E. Fire alarm and emergency communication system control equipment that is installed in non-high-rise buildings, is desired to be located within a room separated from the remainder of the building by not less than a one-hour fire resistance-rated fire barrier. The room should be provided in a location approved by the Division of Emergency Management & Fire Prevention Representative, the University Architect and University Engineer after consultation with the local fire department. Note that not all existing buildings nor Student Life buildings will be required to meet this requirement.
  - F. Provide IP RS-232 / RS-485 interface connection at the FACP for the emergency communication system.
- .1.4 TECHNOLOGY: Each system shall have indicator's showing zone location, zone alarm, zone trouble, and system trouble. The new systems shall be analog addressable with adjustable pre-alarm level, with analog addressable notification devices, and addressable appliances. Panels, devices, and appliances shall be based upon EEPROM memory (electrically erasable programmable read only memory) or "flash" memory, for address, sensitivity, and pre-alarm levels, and shall be programmable in the field by the University. (Panels, devices, and appliances limited to PROM memory, EPROM memory, or RAM memory are not acceptable).
- ALTERNATIVE: Upon written exception from the University Architect, you may design an addition to, or expansion of, any existing system using technology matching the existing hardware. All other performance requirements, with the exception of analog addressable technology, shall be included.
- .1.5 ACCEPTANCE BY THE UNIVERSITY
- A. Acceptance by the University: The system must be scheduled by Emergency Management & Fire Prevention to be demonstrated in the presence of the State of Ohio Fire Marshal (the authority having jurisdiction), A/E, Project Manager, the University's Director of Maintenance, and their designated representatives, Fire System Shop. During acceptance, the contractor shall demonstrate the following to the University's designees:
    - 1. Alarm Verification: - Report by device - Pinpoint location Device type identification and address
    - 2. Alarm/Trouble per device and component
    - 3. Full field programmability via a laptop Windows-based personal computer:
      - Address verify and change,
      - Sensitivity verify and change,
      - Pre-alarm level verify and change,
      - Field changes shall upload to central panels
      - Field changes shall download from central panels
    - 4. Single-button building system, common alarm silence, silences existing and new systems in parallel.
    - 5. Single-button building system, common reset, resets existing and new systems in parallel.
    - 6. Battery power capacity.
  - B. System will not be accepted until all components and functions are demonstrated to be in full operation for a minimum of seven (7) consecutive days without trouble conditions, before claiming substantial completion.
- .1.6 WARRANTY:
- A. Provide full 2-year parts and labor warranty for the entire system including batteries.
  - B. Warranty period shall commence at date of signed University Acceptance.

*Date of manufacture, date of shipment, date of delivery, date of installation, etc. shall not constitute date of warranty commencement for the purpose of the project.*



- C. For small renovation projects provide the standard 1-year parts and labor warranty.
- .1.7 TRAINING FOR DAILY OPERATION: The following training for daily operations shall be specifically included: One full instructor-day, minimum 8-hours, divided into two 4-hour training modules covering the same instruction, of on-site instruction for the daily operation of the system, to be attended by the University's designated Operations personnel. All training shall be scheduled by the contractor in coordination with Facilities Operations and Development, Training Officer, and their designated representatives. All training shall be video recorded. The A/E shall consult with Facilities Operations and Development's Fire System Shop and Technical Services Group on the appropriate level of training requirements for each project.
- .1.8 TOOLS: Provide OEM hardware tools and documentation, OEM software tools and documentation and password.
- .1.9 TRAINING FOR SYSTEM MAINTENANCE: For New Fire Alarm System Models or significant changes to existing models that require manufacturer certification training to be authorized to work on the system:

**Commentary:** The University desires to become self-sufficient and skilled to perform regular preventive maintenance, annual system inspections, remedial maintenance, and small renovations.

The A/E and PM shall consult with Facilities Operations and Development's Fire System Shop and Technical Services Group on the appropriate level of training requirements for each project.

In addition to the above training for daily operation, \_ an allowance may be established \_\_ for system maintenance training, including the OEM manufacturer's certification standards for:

OEM training on the use of the \_OEM hardware and software tools, and OEM certificate of "Authorized Warranty Service Technician" or equivalent. All training and diagnostics shall be identical to that as provided and available to the factory authorized service representatives. The training shall allow the University to perform all maintenance and inspection functions. The hardware tools shall include EEPROM programmers using industry standard laptop personal computers. The software tools shall perform on industry standard Windows-based laptop computers, using industry standard MS-Windows operating systems. The training shall be conducted by the manufacturer's trainers, and shall include classroom hands-on training.

**Commentary:** Training budget to consider travel allowance for two (2) University employees - including per diem expenses for hotel room(s), meals and incidentals based on Federal Government GSA rates ([www.gsa.gov](http://www.gsa.gov)) in addition include an allowance for a rental car.

- .1.10 ANNUAL INSPECTIONS: The system, devices, and applications, along with OEM training of the University's Operations personnel, shall allow the University to perform the "One Person Walk Tests" by area, location, device, address, or system. The tests shall include:
- A. Full System
  - B. Area
  - C. Alarm/Trouble
  - D. Silent/Audible Modes
  - E. Printed Record of All Tests
  - F. Audible Appliance Type & Identification
  - G. Auto "Timed-Out" With Warning
- .2 SYSTEM TYPE AND FUNCTIONS: System shall be analog, addressable, adjustable pre-alarm level, non-coded, continuous alarming type. An alarm shall continue to notify until the initiating device has been restored, and the single-button common building system reset switch has been operated.
- .2.1 WIRING AND POWER: This Standard requires the following:
- .2.1.1 All wiring for the Fire Alarm Systems shall be color coded.
  - .2.1.2 Each wire shall have a numbered tag at both ends.
  - .2.1.3 All fire alarm wiring shall be run in a 3/4" minimum conduit size and conduit system separate from all other systems. Conduit compression couplings shall be required to be used for all fire alarm system conduits. The use of full wall flexible conduit shall be limited to short lengths where fire alarm appliances are mounted on suspended acoustical ceilings, tamper and flow switches and Type LA Liquidtight Flexible Conduit for wet, oily conditions (e.g. fire pump motor leads) both types shall be UL listed for use in accordance with the NEC.  
  
*Commentary: Provide compression couplings per all U.L. Listed tested assemblies and as a requirement to reduce the opportunity for water to entry the conduit system and cause damage to fire alarm panels.*
  - .2.1.4 All Power-Limited Fire Alarm Circuit (PLFA) system wiring shall be stranded and/or solid copper, minimum 75 degree C insulation, Type FPLP, FPLR, and XHHW-2 for Utility Plant applications, and shall be used for initiating and communicating devices as permitted by National Electrical Code (NEC -760). All Non-Power-Limited Fire Alarm (NPLFA) circuits shall be stranded and/or solid copper Type THW or XHHW and XHHW-2 for Utility Plant applications as permitted by National Electrical Code (NEC-760). The A/E is required to witness the wire type on site prior to the wire being pulled.
  - .2.1.5 Nylon insulation jacketed cables are prohibited. THHN/THWN cables are prohibited for use in fire alarm systems.
  - .2.1.6 Flame retardant PVC jacketed cables are required. Cable must have resistance to flame spread and reduce smoke generating properties.  
  
*Commentary: Purpose of the rating is to lessen the transmission of fire and visible smoke to unaffected parts of the building.*
  - .2.1.7 Cabling for the floor's fire alarm system devices: The cable shall not penetrate floors or ceilings (i.e. cable may only be used within a single floor).
  - .2.1.8 Grounding: All fire alarm systems shall be grounded. The grounding shall be connected to the building's electrical grounding system. Refer to Building Design Standards 26 20 06.
  - .2.1.9 Network Riser cable shall have a two-hour fire-resistive rating. The A/E shall review the method to be used to achieve the rating with Facilities Operations and Development's -Technical Services Group.

- .2.1.10 Final connection between equipment and the wiring system to be made under the direct supervision of a representative of the manufacturer.
  - .2.1.11 All wires shall be terminated with ring or split terminal crimp on connectors.
  - .2.1.12 All fire alarm system wiring shall be plenum rated.
  - .2.1.13 Firefighters two way communication, when required shall be by a Distributed Antenna System for Firefighter RF Radio System.
  - .2.1.14 Splicing of power and or/or control wiring and the use of wire nuts is prohibited.
  - .2.1.15 Cable Taps: Use numbered screw terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made. Use split terminal crimp on connectors.
  - .2.1.16 Wiring within enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams.
  - .2.1.17 Network Access Control (NAC) Panels are to be wired as a circuit to the Fire Alarm Control Panel with 2-hour Fire Rated Cable. Buildings with multiple Fire Alarm Control Panels and/or Transponder Panels shall be wired as a circuit to the Command Center's Fire Alarm Control Panel with 2-hour Fire Rated Cable.
- .2.2 Multi-conductor Non-Power-Limited Fire Alarm Cables are permitted to be installed as wiring within buildings for the following locations:
- A. Space used for Environmental air-handling purposes.
  - B. In exposed or fished in concealed spaces.
  - C. Where passing through a floor or wall in metal raceway.
  - D. In rigid non-metallic conduit, such as over hung ceilings and for wiring in ducts and plenums. This does not include habitable rooms or areas of buildings, in which the main purpose is not air handling, or the joist and stud spaces of dwelling units. It shall be used or permitted on Fire Alarm circuits operating at 150 Volts or less. All initiating devices, all notification appliances, and all panels shall be under constant electrical supervision. An open or ground in any wire shall cause a trouble alarm to operate. The systems shall include battery standby power. Systems shall indicate a trouble alarm upon loss of battery standby power, and shall close a separate dry contact output. When commercial AC power is restored, the systems shall automatically revert to AC power, without operator intervention. Batteries shall be sized to provide a minimum of 24 hours of monitoring, plus 5 minutes of 100% full alarm output. Recharging systems shall be sized to recharge all batteries to 100% capacity within 12 hours. When the system is operating on battery for one minute, the fire door relays shall release to conserve battery power. Locate trouble alarms in a public area.
- .2.2.1 Batteries:
- A. Batteries shall be sealed lead acid with a nominal life expectancy of 5 years, minimum. Batteries shall be manufactured in the USA, stamped with ship date from the manufacturer and stamped with the date of system activation. Batteries shall not be stored in excess of one month without having a continuous trickle current applied to maintain charge. A/E and University Representative shall witness the fact that the batteries are being charged.
  - B. Batteries shall not be shipped and installed in the panels until the system pre-test is to be done by manufacturer's technician.
  - C. Perform and record a battery load test after Fire Life Safety Inspection is completed and submit this information to the A/E.

- D. At the end of the two (2) year warranty period all batteries will be retested by the -manufacturer and witnessed by Facilities Operations and Development's Fire System Shop representative -. The batteries that have amp-hour capacity below 80% of the original manufactured ratings shall be replaced, material and labor, at no additional cost to the University.
  - E. Provide battery-charging circuitry for each standby battery in the system. The charger shall be automatic in design, adjusting the charge rate to the condition of the batteries. All system battery charge rates and terminal voltage shall be read using the fire alarm control panel LCD display in the service mode, indicating directly in volts and amps. Meters reading in percentage are not acceptable.
- .2.2.2 All field wiring for Fire Alarm Control Panel and accessory control panels shall enter a 4 x 4 duct (min.) located to the side or bottom of the panels. No connections other than through the side or bottom of panels and through the 4 x 4 duct shall be permitted.
- .2.2.3 CLASS of CIRCUITS:
- A. Initiating Device Circuits shall be Class A.
  - B. Signaling Line Circuits shall be Class A.
  - C. Notification Appliance Circuits shall be Class A.
- .2.3 INDIVIDUAL INITIATION CIRCUITS: Design the initiation circuits to be zoned and separated as follows:
- A. Manual devices (all pull-stations) shall report independently from automatic devices (smoke detectors).
  - B. Sprinkler flows shall report independently from other devices.
  - C. All other devices shall be zoned as required per codes and application.
  - D. Address assignments on any single circuit shall not exceed 75% of the address capacity of the circuit, to allow for future expansion.
  - E. Power draw and/or voltage drop on any single circuit shall not exceed 75% of the power and/or voltage limitation of the circuit, to allow for future expansion.
- .2.4 MANUAL DEVICES: Manual devices (all pull-stations) shall be addressable, surface mounted or semi-flush mounted as conditions dictate. New stations shall be double-action, with a key reset. Within any single building, new stations shall be keyed alike, such that a single key will function for both existing and new stations. The contractor shall include necessary labor and materials to unify key requirements within any single building. New stations shall be so arranged that they cannot be reset to normal without the use of a local key. The use of a local key shall not include code wheels, or code devices.
- .2.5 AUDIBLE Notification Appliances: Speakers and horns, shall be located so that their operation will be heard clearly in all areas regardless of the ambient level. Alarm appliances shall be designed for parallel connection, Class A, style-D type circuit, DC operation.
- A. Notification devices on any single circuit shall not exceed 75% of the capacity of the circuit, to allow for future expansion.
  - B. Power draw and/or voltage drop on any single circuit shall not exceed 75% of the power and/or voltage limitation of the circuit, to allow for future expansion.
  - C. Where emergency communication systems are provided, fire alarm speakers must be installed in elevator cars and exit stairways; however, they must only be activated to broadcast live voice messages (e.g., manual announcements).

The automatic voice messages shall - be broadcast through the fire alarm speakers on the appropriate floors, but not in stairs or elevator cars.

.2.5.1 Visible Notification Appliances: All audible alarms shall be equipped with a flashing strobe light. It is also required that the strobe shall be equipped with synchronized light bursts. Visible notification appliances are to be installed in public and common areas including public rest rooms, reception areas, building core areas, conference rooms, open office areas, mechanical rooms and so on and shall be part of an audible/visual device. Visible notification appliances are not permitted to be installed in exit enclosures or elevators (e.g., exit stairs). Visible notification appliances shall be of the same manufacturer and capable of being synchronized.

***Commentary:*** There may be occasions where an independent speaker is required (e.g. elevators, stairways). Synchronization of visible notification appliances is an important consideration for additions to buildings and when partially updating an existing fire alarm system. Verify that the new visible notification appliances can be synchronized with the existing visible notification appliances.

## .2.6 ANALOG ADDRESSABLE DEVICES

.2.6.1 HEAT DETECTORS: Heat detectors shall be field-restorable, and may be either fixed temperature or rate-of-rise type, as the need requires. The selection and location of these detectors shall include consideration for ambient temperatures, and area to be covered. The devices shall be analog, addressable, and shall permit the University to adjust address, sensitivity, setpoint, and pre-alarm levels.

.2.6.2 SMOKE DETECTORS: Smoke detectors shall be two-wire and multi-sensor detectors with both photoelectric and thermal inputs, subject to the approval of the University. The devices shall be analog, addressable, and shall permit the University to adjust address, sensitivity, and pre-alarm levels. Examples of acceptable sensitivity test methods are as follows:

- A. Analog Addressable systems: Access the system's "Test" function at the main control panel and request a test report for detector address, sensitivity and pre-alarm setting.
- B. Non-Addressable systems: Place a test magnet on the detector and the detector shall then respond with a series of coded beeps and/or flashes that indicate a certain sensitivity range.
- C. When smoke detection is installed in rooms having high voltage equipment, the smoke detection shall not be installed directly above high voltage equipment.
- D. Existing smoke detectors scheduled for demolition that contain radioactive material cannot be disposed as demolition waste. Contact the Hazardous Waste Supervisor for the Office of Environmental Health and Safety (EH and S) for specific instructions regarding proper storage, to make arrangements to obtain containers, as well as pickup and disposal arrangements. There is no charge for these services; seven days advanced notice is required to schedule with EHS (separate notice for container delivery and also for pickup).
- E. Aspirating Smoke Detection Systems: Review the appropriate use and application of this type of system with the University Architect and University Engineer.
- F. Provide addressable module for non-addressable devices as required.

.2.6.3 LED's FOR HIDDEN DETECTORS: When detectors and flow switches are installed hidden from plain view, remote LED notification lights must be installed at the ceiling line to show the location of the hidden detectors.

- .2.7 REMOTE MONITORING: The University has centralized the monitoring of all security and other critical alarms. The Access Control and Alarm Monitoring System (ACAMS) uses a proprietary remote monitoring system based upon Lenel Intelligent System Controller equipment. The remote monitoring communication panels are located at the buildings. The System shall be installed and comply with Section 28 10 10 of this Standard. All Columbus campus buildings, excluding the University Hospitals and regional campuses, shall require 24-hour remote reporting and monitoring, and shall use this system, and shall report to DPS Communications & Security Technology Division Central Alarm Center and the Facilities Operations and Development Service Center. The regional campus buildings shall report to their respective security centers. The fire alarm system shall report the following (via dry contact output) to the remote monitoring system:
- A. Common Building Fire Detection Alarm
  - B. Common Building Fire Detection Trouble
  - C. Common Building Fire Suppression Alarm
  - D. Common Building Fire Suppression Trouble

The Designer shall make certain that the existing and new Fire Alarm System are integrated into the Lenel Intelligent System Controller (LISC) as one common building Fire Alarm System. The Lenel Intelligent System, also reports Building Intrusion Detection Alarms and troubles. The Designer shall follow the guideline and direction of Section 28 10 10 of this Standard.

- .2.7.1 ADDITIONAL REMOTE MONITORING FOR STUDENT LIFE BUILDINGS: All Student Life buildings shall be monitored by the Student Life Building Automation System, where it is applicable, in addition to remote monitoring by Lenel. Note that Lenel is not available on the regional campuses:
- A. Common Building Fire Detection Alarm
  - B. Common Building Fire Detection Trouble
  - C. Common Building Fire Suppression Alarm
  - D. Common Building Fire Suppression Trouble

.3 ADDITIONAL COMPONENTS:

- .3.1 CONTROL UNITS: Control unit shall be installed in a suitable steel cabinet with hinged cover, secured with lock and key. The control cabinet shall include:
- .3.1.1 Line terminals for 120-volt single-phase power.
  - .3.1.2 Single-button building system, common alarm silence switch, silences existing, and new systems in parallel.
  - .3.1.3 Single-button building system, common reset switch, resets existing, and new systems in parallel.
  - .3.1.4 Remote signaling relays shall function with the Fire Alarm Control Panel (FACP) for:
    - A. Release of fire doors,
    - B. Shutdown of ventilation systems,
    - C. Remote annunciation
    - D. Elevator recall

**Commentary:** *Elevator smoke detector recall shall not be a standalone function, but shall function with the FACP that reports alarms and troubles to OSU Department of Public Safety (DPS).*

## DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

---

- .3.1.5 Power to the control unit shall be limited to not more than 75 percent of the supply circuit capacity (power and/or voltage) rating.
- .3.2 ANNUNCIATORS: Annunciators and remote annunciators shall be equipped with identical displays. All annunciators and remote annunciators shall be fully supervised by the system, and the system shall audibly and visually indicate the fault of either component. Remote annunciators shall be a UL listed component as a UL listed control unit. Annunciator signals shall remain locked in until the annunciator is manually reset from the remote single-button building system common reset. Include annunciators to provide location/address identification where any of the following conditions exist:
  - .3.2.1 Automatic devices are connected to the fire alarm system.
  - .3.2.2 A building has four or more fire zones. Each area on a floor separated by a firewall shall be considered a zone.
  - .3.2.3 Type: Lighted window type, operated from the zone controls of the fire alarm panel. Separately wired annunciator circuits are not approved. Signals on the annunciators shall remain locked in until manually reset.
  - .3.2.4 Location: Locate annunciator at the control panel and at other locations in the building that serve as the immediate access for the Fire Department to that building. The A/E shall consult with the Division of Emergency Management & Fire Prevention and Facilities Operations and Development's Technical Services Group for the purpose of determining the building entrances that will customarily be used by the Fire Department. At the determined building entrance provide a Security LockBox. Contractor to purchase Security LockBox from Facilities Operations and Development's Mechanical Electrical Shop.
  - .3.2.5 For additions to existing systems, the added annunciation shall be located at the same location as the existing annunciator panels.
- .3.3 SPARE MATERIALS, SERVICE STOCK: Spare initiating devices (smoke detectors, heat detectors, rate-of-rise detectors, manual pull stations, flow switches, valve tamper switches, contact monitoring units, bases, etc.) and notification appliances (horns/strobes, speaker/strobes, relays, bases, etc.) shall be furnished to the University by the contractor. Quantities shall be the larger of:
  - .3.3.1 No less than 1 of each item, or
  - .3.3.2 Minimum 10 percent of each item, whichever is the greater quantity.
  - .3.3.3 Deliver spare materials to the Fire System Shop.
- .3.4 AS-BUILT DRAWINGS: Provide a set of as-built drawings, plastic covered, of the fire alarm system indicating wiring layout, and manufacturer's device data sheets in a three ring folder. Provide a two or three-compartment steel wall pocket mounted on the wall - next to the fire alarm panel and place the drawings and folder there. Provide an additional set of record fire alarm drawings and data sheets in a folder to FOD's Fire System Shop. Include the fire alarm drawings and manufacturer's data sheets - in the operation & maintenance manuals, and in PDF format as well. Provide a copy of the original software program and all updates of the program to Facilities Operation and Development's Fire System Shop on a USB Flash Drive or other agreed method.
- 4 SPECIAL REQUIREMENTS FOR FIRE ALARM SYSTEMS INSTALLATION AND REVIEW.
  - 4.1 Architect/Engineer shall make certain that device locations (Address or Location(s)/Life Safety) are shown and listed for review on the drawings. A/E shall provide the fire alarm system riser diagram and function matrix on the Bid drawings. A/E shall include the room number locations for the fire alarm control panel, annunciator panel, and PAD, NAC and Transponder panels, and Lenel panel. A/E shall review all fire alarm shop drawing submittals and after corrections have been made submit to the Authority Having Jurisdiction. A/E shall coordinate room numbers with the University Project Manager and shall include the following statement in the specifications:

## DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

---

- “Prior to final programming of Fire Alarm System room numbers shall be verified for correctness.”
- .4.2 Program buttons on all main Fire Alarm panels shall be programmed as required.
  - .4.3 Specify that room(s)/area(s) with multiple devices have higher priority.
  - .4.4 Specify that the Contractor shall provide a copy of Fire Alarm program in every installation on a USB Flash Drive or other agreed method to the Architect/Engineer as part of closeout documents.
  - .4.5 Record Documents including Controls, Fire Alarm Riser Diagram for the building’s complete fire alarm system, etc. shall be on AutoCAD and shall be submitted to the University at substantial completion of the project and before the final payment shall be made by The University.
  - .4.6 Fire Alarm Systems shall be capable of providing a single BACnet communications output with IP Connection, but do not provide this equipment unless specifically requested by Facilities Operations and Development’s Fire System Shop.

END OF DIVISION 28 – ELECTRONIC SAFETY AND SECURITY



## **DIVISION 31 – EARTHWORK**

2006 Edition, Published January 1, 2006; Division Revision Date: January 31, 2012

### **PART FIVE DOCUMENTS FOR SITE AND INFRASTRUCTURE**

#### **31 00 00. EARTHWORK**

##### **31 10 00. SITE CLEARING**

- .1 STRUCTURE REMOVAL: Include structure removal in DIVISION 02, Section 02 41 00 DEMOLITION.
- .2 EXPLOSIVES: Use of explosives or blasting as a construction practice is prohibited, except when approved in writing by the University Architect for special cases.

##### **31 11 00. CLEARING AND GRUBBING**

- .1 CLEARING: All objectionable growth shall be stripped. Debris resulting from stripping and clearing operations shall be promptly removed from University property so as to prevent this material from accumulating on the site.
- .2 GRUBBING: Removal of trees and shrubs shall include the removal of stumps and roots to the extent that no root greater than 3 inches in diameter remains within 5 feet of an underground structure or utility line or under footings or paved areas. Grubbing in open areas shall include removal of stumps and 3 inch roots to 2 feet below finish grade elevations.
- .3 PROTECTION OF TREES: Existing trees indicated to remain shall be protected by boxing. Boxing shall be 4 by 4 inch posts with two 2 by 4 inch rails, approximately 8 by 8 feet centered on tree trunk, to a height of approximately 5 feet. Some specimens will require fencing at the drip line of the branches. Do not store anything within the drip line of any trees.
- .4 PROTECTION OF SPECIAL TREES AND SHRUBS: Trees and shrubs are of such value that special attention of the contractor must be directed to protection for them. The University Landscape Architect shall be consulted by project specific document notes and details for protection of trees. A monetary value has been assigned to every tree on OSU property. The contractor will pay the listed value for any tree that dies as a result of the construction process. Consult the University Landscape Architect for current tree values.
  - .4.1 Occasionally, protection of a specimen will require fencing at the drip line of the branches; or, if the specimen is in danger from objects falling on it, a sturdy roof over the tree or shrub may be required.

##### **31 22 00. GRADING**

- .1 Unless otherwise specified by these standards and regulations, all site grading shall be designed to meet the following standards:
  - .1.1. Planting/Lawn Areas
    - a. Minimum Slope: 2%
    - b. Maximum Slope: 33%

## **DIVISION 31 – EARTHWORK**

---

- .1.2. Parking Lot Pavement
  - a. Minimum Slope: 1.5%
  - b. Maximum Slope: 4%
- .1.3. Pedestrian Plaza Areas
  - a. Minimum Slope: 1%
  - b. Maximum Slope: 2.5%

### **31 23 00. EXCAVATION AND FILL:**

- .1 MATERIALS FOR FILL AND BACKFILL: Specify only materials which can be compacted, without containment, to the densities specified by Architect/Engineer (A/E).
- .2 SOIL COMPACTION CONTROL: Compaction control shall be provided for all fill, backfill, and embankments, both inside and outside the perimeter of the structure. Field compaction tests and related laboratory analyses shall be performed by a qualified independent laboratory (a member of the American Society for Testing and Materials), under the supervision of a registered professional engineer specializing in soils engineering. Soils proposed for fill, backfill, and embankments shall be analyzed by the soils engineer to determine acceptability; no soil shall be placed until it is approved by the soils engineer. A representative of the testing laboratory shall provide continuous inspection during placement and compaction operations; tests shall be made in a quantity that will assure uniform compaction and density of each course, or lift, of fill.
  - .2.1 UTILITY TRENCH: Minimum utility trench cut width shall be 2' to allow for proper compaction. A/E shall show a detail of utility trench cut with the minimum width of cut being called out on the plans or make reference to City of Columbus Standard Drawing 1441 DR.A "Pavement & Utility Cut Repair Standards".
- .3 PAYMENT FOR LABORATORY SERVICES: The testing laboratory shall be made responsible to the A/E. All costs for tests and analyses performed shall be paid from Project Funds on an actual cost basis without fee mark-up. The testing laboratory shall be made responsible to the A/E. Written reports of field tests shall be submitted directly to the A/E, the responsible contractor and the University Architect.
- .4 COMPACTION REQUIREMENTS: Specify that soils be compacted to the following densities, as determined by Standard Proctor Tests:
  - .4.1 ROAD BEDS: Compaction shall conform to requirements specified in the latest edition of the City of Columbus, Ohio Construction and Material Specifications, Item 204 for all work within Franklin County and the State of Ohio, Department of Transportation Construction and Material Specifications, Item 204 for work outside of Franklin County. Compaction is required for the entire subgrade area for the full width and depth of slope of the embankment supporting the berm and pavement.
  - .4.2 INSIDE STRUCTURES:
    - .4.2.1 UNDER NON-STRUCTURAL SLABS ON GRADE, with normal loading: 98 percent, standard Proctor test procedures (ASTM D-698).

**DIVISION 31 – EARTHWORK**

---

.4.2.2 UNDER SPECIAL FOUNDATIONS, ISOLATED PADS, AND FOOTINGS: 100 percent, standard Proctor test procedures (ASTM D-698).

.4.3 OUTSIDE THE STRUCTURES:

.4.3.1 TRENCH COMPACTION Under paved surfaces shall be as described below except that shallow trenches shall be filled with flowable controlled density fill (FCDF) Type II per City of Columbus specifications 636 and topped with 3 inches of City of Columbus Item 404. Deep large volume trenches under paved surfaces shall be benched 12" back from the face of the excavated trench and filled and compacted as described below and at least the top 15 to 18 inches of trench shall be filled with 12 inches of material control density fill and topped with 3 inches of City of Columbus Item 404.

.4.3.2 PARKING AREAS: The top 1 foot of subgrade shall be compacted to 100 percent of maximum dry density.

Remainder:

Maximum Laboratory Dry Weight (lbs./cu. ft.)	Minimum Compaction Percent of Laboratory Maximum
90.0 - 104.9	102
105.0 - 119.9	100
120.0 and more	98

.4.3.3 FOUNDATION BACKFILL UNDER PLANTING BEDS AND LAWN: The upper 2 feet of soil below finish grade - 92 percent maximum. Remainder of backfill - 95 percent if depth is less than 10 feet; - 100 percent if depth exceeds 10 feet.

.4.3.4 FOUNDATION BACKFILL UNDER PAVEMENTS: 100 percent, standard Proctor test (ASTM D-698).

.4.3.5 UNDER PAVED PEDESTRIAN WALKS AND COURTS: 98 percent, standard Proctor test (ASTM D-698).

Specify that extreme care be exercised to obtain proper compaction under edges of walks which abut walls, stairs, curbs, adjacent slabs, and other structures where use of mechanical compactors is made difficult.

.4.3.6 BACKFILL AROUND MANHOLES AND OTHER UNDERGROUND STRUCTURES: 98 percent if depth is less than 10 feet; 100 percent if depth is more than 10 feet.

.4.3.7 UNDER LAWN AND PLANTING AREAS WHICH ARE NOT ADJACENT TO STRUCTURES: The upper 1 foot of soil below finish grade - 92 percent maximum. Remainder - 95 percent. Exception shall be taken for the areas designed as storm water best management practices (BMPs) which may have different compaction requirements.

.4.3.8 DENSITY OF TRENCH BACKFILL shall be equal to densities specified for all adjacent fill and backfill.

## **DIVISION 31 – EARTHWORK**

---

- .5 DISPOSAL OF EXCESS: Excess fill material or topsoil which is not required nor permitted as fill shall be removed from University property at the contractor's expense.

### **31 25 00. EROSION AND SEDIMENTATION CONTROLS**

#### **.1 TEMPORARY SEDIMENT AND EROSION CONTROLS**

- .1.1 Reference the City of Columbus (COC) Construction and Material Specifications Item 207 for temporary sediment and erosion control materials and requirements for work within Franklin County. Reference local codes or the State of Ohio Department of Transportation (ODOT) Construction and Material Specifications Item 207 for work outside Franklin County, whichever is more stringent.
- .1.2 Inspect, repair, and clean erosion control blankets after each rain event.

### **31 60 00. SPECIAL FOUNDATIONS AND LOAD-BEARING ELEMENTS**

- .1 TYPES OF FOUNDATIONS: The A/E, in consultation with his structural consultant, shall determine the type of foundation best suited for the structure, as indicated by soil conditions and other conditions at the site. Before a decision is made to use pile foundations, the A/E shall make a thorough examination of structures and occupancies adjacent to the site to determine what effect vibratory forces will have on such structures, occupancies and equipment. At the A/E's option, foundations may be a system of precast or cast-in-place concrete piles, steel piles, concrete caissons, or a combination of piles and caissons. Wood piles, helical piers and push piers are prohibited.
- .2 DESIGN: Design shall be by a professional engineer, registered in the State of Ohio, and drawings shall bear the seal and signature of the engineer.
- .3 LABORATORY SERVICES: An independent laboratory shall be employed to devise tests, in cooperation with the A/E's consultant, to perform testing of piles and to provide continuous inspection of pile driving and caisson construction to assure conformance with the drawings and specifications.
- .3.1 PAYMENT FOR LABORATORY services shall be as specified for soil compaction control in paragraph 31 23 00.2.
- .3.2 TEST PILES: Specify that the laboratory, in cooperation with the consultant, locate piles and employ the contractor to drive a minimum of 3 test piles before any other pile driving is started. Location of piles shall be such that, if tested piling meets requirements specified, these piles may be used in the building foundation system.
- .3.3 TEST REPORTS FOR ALL PILES SHALL INCLUDE: Date of driving; locations; grade designation and dimensions of pile; pile point reinforcement and description, if any; total penetration; starting and finishing times, and total driving time; number of blows required for each foot of penetration, total number of blows, and resistance in blows per inch for the last 6 inches of driving. Include a record of driving equipment used: hammer make and model number, stroke, weight of ram, and rated driving energy, driving cap weight and description, actual rate of operation of hammer during driving.
- .4 PAYMENT: Specifications shall contain statements that the base bid price for the work be based on depths of piles, or caissons, as shown on the drawings and on soil boring data.

## **DIVISION 31 – EARTHWORK**

---

The Bid Form shall contain spaces for amount per linear foot to be added to or deducted from base bid for depths differing from those indicated. A statement must be made that payment to the contractor will not be made for extra pilings which are driven for his own use while conducting the work. The A/E must certify the depths of pilings, or caissons, upon which the contractor's cost is based. A statement must also be made about the method of calculating the adjusted cost for pilings actually driven. Method of calculation should be that which is least expensive for the University since bidders usually indicate lower amounts for deducted than for added footage.

### **31 63 26. DRILLED CAISSONS**

- .1 INSPECTIONS: The testing laboratory and the A/E's consultant shall make continuous inspections of all operations during excavation, casing installation, and placement of concrete.
- .2 DATA REPORTS SHALL INCLUDE: Date; weather; time; identification mark; shaft diameter; bell diameter; top elevation; bottom elevation; bearing strata description; nature and location of obstructions; and water conditions during drilling and concrete placement.

---

END OF DIVISION 31 - EARTHWORK

## **DIVISION 32 – EXTERIOR IMPROVEMENTS**

2006 Edition, Published January 1, 2006; Division Revision Date: November 30, 2015

### **32 00 00. EXTERIOR IMPROVEMENTS**

#### **32 10 00. BASES, BALLASTS, AND PAVING**

1. GENERAL PROVISIONS: Specify that construction of roads, drives, service courts, and parking areas, including subgrade and other related work, must be performed by a contractor fully qualified and equipped to construct roads.
- .2 DESIGN DETAILS:
  - .2.1 MINIMUM TURNING RADII FOR STREETS, DRIVEWAYS, & LOADING DOCKS: 20 feet for automobile traffic; 30 feet for truck traffic, and 50 feet for bus and garbage truck traffic. When possible, or appropriate, use greater radii. Loading dock radii should be determined using the largest possible vehicle and must be approved by the University.
  - .2.2 SPECIAL DRAINS: In stairwells, areaways and similar locations where leaf clogging of conventional drains would be expected provide scupper type drains at the junction of the wall and pavement or walk. Piping size shall be 6" in diameter minimum.
  - .2.3 MANHOLES AND CATCH BASINS: Refer to City of Columbus (COC) Construction and Materials Specifications Item 604 and Standard Drawings for manhole and catch basin materials and requirements for work within Franklin County. Refer to the more stringent jurisdiction between local codes or State of Ohio Department of Transportation (ODOT) Construction and Materials Specification Item 604 and Standard Drawings for work outside Franklin County.
- .3 PROHIBITED CONSTRUCTION:
  - .3.1 Mortar joints between unit pavers. See Appendix K
  - .3.2 CHIP SEALING or shoot and chip surfacing for permanent parking lots, walks, streets or drives.
- 4 WALKS: Minimum width shall be 8 feet. See The Ohio State University walk policy in Appendix.
  - .4.1 University policy dictates concrete walkways in the absence of overriding considerations. Any deviation from concrete walks requires the approval of the University Landscape Architect. Pavers, such as 4"x8" clay brick pavers or natural stone pavers, shall be used as adjunct surfaces for appropriate areas to provide for improved drainage, to protect the viability of plant materials, or for design purposes.
    - .4.1.1 Deviations from the policy above shall be permitted in those areas where a predominant character has already been established for walkways by use of other materials.
  - .4.1.2 Deviations from the policy shall also be permitted in especially defined areas (field areas, gardens, natural areas, special feature sites, etc.) where the use of concrete walkways or masonry pavers would clearly be inappropriate or where structural considerations apply.

### **32 12 00. FLEXIBLE PAVING**

#### **32 12 16. ASPHALT PAVING**

- .1 GENERAL PROVISIONS: Specify asphalt paving materials by reference to City of Columbus (COC) or State of Ohio, Department of Transportation (ODOT), Construction and Materials Specifications (CMS) with the exception that limestone aggregate, only, be used in asphalt concrete.

## DIVISION 32 – EXTERIOR IMPROVEMENTS

---

- .2 PAVEMENT DESIGN REQUIREMENTS: Architect/Engineer shall employ a geotechnical engineer to conduct subsurface exploration and follow the recommendations with regards to subgrade preparation and pavement composition. Pavement design shall meet the latest COC and ODOT published methodology with a design life of 30 years.
- .2.1 Design Considerations:
- a. Average Daily Traffic Projections
  - b. In-situ subgrade soil conditions
  - c. Construction traffic impact
  - d. Bus/Heavy Truck impact
  - e. Life Cycle Cost analysis
  - f. Location of utilities
  - g. Recycled properties of materials
  - h. Heat Island effect
  - i. Cost of Materials
  - j. Additional section to be considers, based on importance of road
- .2.2 Estimating Guidelines:
- .2.2.1 Parking Lots without heavy loads
- a. No bus, loading docks, through traffic, and/or trailer parking
  - b. Less than 300 spaces
  - c. Composition ~ 8" of aggregate, 4 ¼" of asphalt
- .2.2.2 *Parking Lots with heavy loads*
- a. Bus and/or trailer parking
  - b. More than 300 spaces
  - c. Composition ~ 10" of aggregate, 4 ¾" of asphalt
- .2.2.3 Entrance drives and side roads without heavy loads
- a. No bus, construction, loading dock, and/or garbage truck traffic
  - b. Composition ~ 10" of aggregate, 6 ¾" asphalt
- .2.2.4 Roadways with heavy loads
- a. Bus, construction, and/or garbage truck traffic
  - b. Composition ~ 6" of aggregate, 8" of concrete, 3" of asphalt
- .2.3 Approval:
- k. Parking Lot
    - a. Transportation and Parking
    - b. University Engineer
    - c. University Landscape Architect
  - l. Roadway and Sidewalk
    - a. FOD - Operations
    - b. University Engineer
    - c. University Landscape Architect
- .2.4 BASE DRAINAGE: Perforated underdrain shall be specified along the edges of pavement as well as at the catch basins in the paved area to help drain the subbase.
- .2.5 PROTECTION OF SURFACE COURSE: After completion of surface course, no vehicular traffic or parking shall be permitted on the pavement until the surface is ready to receive traffic without damage.
- 2.5.1 SEALER FOR PARKING AREAS: If the budget will permit such expenditure, specify that parking areas be sealed with 2 coats of coal tar emulsion conforming to U.S. Air Force and Federal Specifications RP-00355 (GSA-

## DIVISION 32 – EXTERIOR IMPROVEMENTS

---

FSS), or an asphalt rejuvenating agent of a petroleum resin oil conforming to ASTM D-244, ASTM D-2006-70 and ASTM D-92.

- .2.7 REPAIRS: Depressions and abutments to existing pavement shall be repaired by cutting out the surfacing to a minimum depth of one inch with vertical cuts, filling, and rolling the areas. Feathering of patches and abutments to existing pavement is prohibited.
- .2.8 JOINT SEALERS: When new pavement abuts existing, the joint shall be sealed per COC Item 413. This applies to all trench repairs.
- .3 WALKS: Asphalt walks, when permitted, shall be a full 2-inch compacted thickness of No. 404 on a 4-inch compacted thickness of No. 304 base. The base and the bituminous material shall each be compacted to 98 percent of their test densities.
  - .3.1 Consider possibility of walks being used as drives, snow removal, etc.
- .4 PAVEMENT REPAIR DUE TO UTILITY TRENCHING: Comply with City of Columbus Standard Drawing 1441 DR. A "Pavement & Utility Cut Repair Standards".

### **32 13 10. RIGID PAVING** **32 13 13 CONCRETE PAVING**

- .1 PAVING: The use of concrete for roads, drives, service courts, and parking areas is desired if the budget permits such construction. Trash dumpsters for construction debris must be parked on concrete pads. All loading docks and ramps shall be constructed with concrete.
- .2 Walks: Thickness shall be 5-1/2 inches minimum over 4 inches of compacted No. 304 gravel base. Thicken the edge to 18"x18" where the sidewalk abuts the curbing. The concrete shall have tooled edges which are then disguised by a light/medium broom finish. Except where required for structural purposes, reinforcing bars or welded wire fabric should be omitted. Use City of Columbus Class C or ODOT Class C concrete with clean sand, limestone aggregate, and 4 percent to 8 percent entrained air. Recycled concrete material that meets COC item 304 requirements may be used as the gravel base.
  - .2.1 CURING COMPOUNDS: Specify only non-staining type. It has been found that clear chlorinated rubber compounds cause staining which cannot be removed.
- .3 PAVEMENT REPAIR DUE TO UTILITY TRENCHING: Comply with City of Columbus Standard Drawing 1441 DR. A "Pavement & Utility Cut Repair Standards".

### **32 16 00. CURBS AND GUTTERS:**

- .1 CURBS: Cast-in-place concrete shall be used unless other design is required per specific instruction from University. Comply with City of Columbus or O.D.O.T. Items 499 and 609. Concrete shall be Class C using No. 57 aggregate at 600 lbs. per cubic yard. Slump shall be 4 inches and minimum 28-day strength shall be 4000 psi with 4 percent to 8 percent entrained air.
  - .1.1 EXPANSION JOINTS shall be specified and shall be shown on the drawings. Color of the joint sealer shall match that of the concrete.
  - .1.2 FOUR INCH DRAIN CONDUCTOR in porous backfill shall be installed under all combination curbs and gutters. Conductors shall extend to drainage basins. Combination curb and gutter may be used only to match or repair existing work.



## **DIVISION 32 – EXTERIOR IMPROVEMENTS**

---

.2 CURB RAMPS FOR PERSONS WITH DISABILITIES: See the ADAAG requirements.

.2.1 COMPANION RAMPS: State laws require that when a curb ramp is built on one side of a street, a companion ramp is required on the opposite side of the street. When project limits would normally end within a street intersection, the limits must be extended to allow construction of a companion ramp on the far side of the intersection. For projects in which Federal funding is involved, this requirement must carefully be coordinated with Federal requirements regarding limits of Federal participation. Ramps on University property shall match COC accessible ramp design guidelines.

### **32 17 00. PAVING SPECIALTIES**

32 17 23. PAVEMENT MARKINGS:

.1 PAVEMENT MARKINGS: All pavement markings shall conform to the City of Columbus and ODOT Item 641. Parking lot lines shall be white per COC Item 642. All roadway striping, turn arrows, cross walks, stop bars etc. shall be per COC Item 644-Thermoplastic for asphalt pavement and per ODOT Item 646 – epoxy marking for concrete pavement.

.2 PARKING LOT MARKINGS:

.2.1 Standard Parking Stall: 8.5' x 18'

.2.2 Standard Parking driveway: 24'

.2.3 Accessible Parking Stall: 8' x 18' with either an adjacent 5' loading space or 8' van loading space.

.3 CROSSWALK MARKINGS: Comply with University crosswalk marking details.

### **32 30 00. SITE IMPROVEMENTS**

.1 SITE AND STREET FURNISHINGS: The Ohio State University has standards for a variety of site and street furnishings. Consult the University Landscape Architect (614-292-3673) for a list of acceptable products and the required installation methods.

.1.1 Refer to Division 12 FURNISHINGS, Section 12 93 00 Site Furnishings

32 34 00. FABRICATED BRIDGES:

.1 Engineering drawings for all bridges shall be sealed by a Professional Engineer registered in the State of Ohio.

.2 Unless the structural elements of the bridge are wood, wood for the bridge deck shall not be used to avoid periodic maintenance problems and damage by snow removal equipment. Asphalt is to only be used with the permission of the University Architect.

.3 Bridge live load is to be designed for a minimum of a non-reducible 100 pounds per square foot, unless actual design factor requires more.

.4 Bridge width is to accommodate snow removal equipment.

.5 Bridges shall be ADA accessible.

.6 Weathered steel finish is not to be used if any element of the bridge could be in contact with soil or vegetation, exposed to winter salting of the deck, or any part of the bridge is capable of trapping moisture. The preferred bridge finish is hot dipped galvanized.

.7 Minimum design standards shall be per OSHA and AASHTO requirements.

## DIVISION 32 – EXTERIOR IMPROVEMENTS

---

### 32 80 00. IRRIGATION

- .1 TURF AND PLANT IRRIGATION: Provide a permanent irrigation system if determined necessary by the University Landscape Architect for all new or renovated turf areas and planting beds designed and constructed by the project. All site irrigation system controls shall be compatible with Rainbird IQ central control system. Controllers must include components necessary for communication with central controller. Irrigation system design shall be reviewed by the University Landscape Architect and a representative of university Landscape Services prior to submittal of final drawings.

### 32 90 00. PLANTING

- .1 CONSULTING SERVICES: Refer to PART ONE, paragraph 00033 for possibility of the services of a professional Landscape Architect being required.
- .2 PLANT MATERIALS: Selection of plant materials on the Campus is extremely important. Since this is a teaching laboratory, the varieties selected must be made from a broad range of stock indigenous to the specific locations. Persons selecting materials must not only be knowledgeable about the plants that will survive in the specific area of Ohio but also be able to select those appropriate for the northwest part of Columbus, for example. Be similarly selective for regional campus and OARDC plant materials. A pre-installation meeting shall be conducted with the University Landscape Architect regarding site and landscape work to address the site development and landscape requirements. Refer to the University Landscape Architect for approvals and assistance. See Tree Grading Standard in Appendix Q.
- .3 PLANT LISTS should contain both common and technical names, quantities, and notation of planting delivery method (B & B, bare roots, etc.).
- .4 KEYS: Indexes or keys identifying plants on drawings are prohibited. All planting must be individually identified without the use of code letters, numbers, etc.
- .5 MULCH: Premium grade single shredded hardwood mulch. Exceptions may be taken for the mulch used in storm water best management practices (BMPs). Consult University Landscape Architect for appropriate mulch types used in BMPs.
- .6 PROHIBITED MATERIALS: Landscape steel, plastic, or aluminum edging and weed-control plastic mats or film under mulch beds may not be used without specific approval of the University Landscape Architect.
- .7 PLANTING SOIL: Blended soil mix consisting of ASTM D 5268-92(96), pH range of 5.5 to 7, ASTM C33 course sand, and a minimum of 4 percent organic material content "Com-Til" (or a University approved organic amendment), tested to determine fertilizer and lime recommendations; free of stones 1 inch or larger in any dimension and other extraneous materials harmful to plant growth.
1. Planting soil Source: Reuse surface soil stockpiled on-site. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
    - a. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from agricultural land, bogs or marshes.
    - b. Planting soil shall be subject to inspection and approval by University Representative at the source of supply.

## DIVISION 32 – EXTERIOR IMPROVEMENTS

---

- .8 STRUCTURAL SOIL: Any tree planted in a tree pit situation and/or surrounded by pavement shall use structural soil in a minimum 8'x8'x3' depth planting area.

### 32 91 00. PLANTING PREPARATION

- .1 SOIL PREPARATION: Specify that areas to be seeded or sodded will be properly prepared with a rototiller to the depth of 6 inches. If the area has been compacted during construction, rototill 4 to 6 inches depth to break up the pan, grade level, and apply topsoil (see 32 91 00.2 for acceptable topsoil). ALL ROCKS, GRAVEL, DIRT AND TURF CLOUDS are to be removed prior to seeding. Grade area 1 to 1-1/2" above grade of existing turf; blend edges to existing turf and sidewalks. Over seed areas with seed the rate indicated in 32 92 00.2 and for proper seed selection. The University Landscape Architect must approve any alternate method.
- .2 TOPSOIL PLACEMENT AND GRADING: Specify a 6-inch depth of acceptable topsoil for seeded areas and 12-inch depth for planting areas. Acceptable topsoil is defined as a blended soil mix consisting of ASTM D5268-92(96) soil component, ASTM C33 course sand and "Com-Til" – or a University approved organic amendment, tested to determine fertilizer and lime recommendations. Specify a 4-inch depth of acceptable topsoil with an additional 2-inch depth of "Com-Til" for seeded areas or a 10-inch depth of acceptable topsoil with an additional 2-inch depth of "Com-Til" for planting areas.
- .2.1 Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depression to meet finish grades. Soil abutting walks should be compacted to 95% to prevent settling.
- .2.2 Moisten prepared turf areas before planting soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- .2.3 Restore areas if eroded or otherwise disturbed after finish grading and before planting.

### 32 92 00. TURF AND GRASSES

- .1 TURF: Specify that all unpaved areas not indicated to receive planting be considered as turf areas and shall be seeded or sodded. No sod or Hydro-mulch seeding is acceptable on the University grounds without the approval of the University Landscape Architect. Hydro-mulch seeding will only be considered for large areas or sloping terrain. All debris (rocks, bricks, concrete, clods stumps etc.) will be removed and the area graded before area will be approved for Hydro- mulch seeding.
- .2 TURF GRASS SEED SELECTION: Seed selection is dependent on the site. Timing of the seeding is determined by the date; see 32 92 19.1 for details. If seeding is to be split because of the time of planting, multiply each of the following percentage by 2 for the proper mix at each seeding.
- .2.1 TURF SEED shall be a clean, weed-free mix (a combination of 2 or more different species of turf grass) or blend (combination of 2 or more cultivars of a single turfgrass species); delivered in sealed containers with labels bearing the producer's name and formula of the mix at each seeding.
- .2.1.1 FOR NON-IRRIGATED AREAS: 100% turf type tall fescue with at least 3 different varieties in the mix and 0% weed seed. Apply at a rate of 6-8 lbs. per 1000 sq.ft. No annual rye accepted under any conditions.
- .2.1.2 TURF SEED FOR IRRIGATED AREAS: Standard bluegrass mix with 85% bluegrass with at least 3 different varieties and 15% Perennial Ryegrass

## DIVISION 32 – EXTERIOR IMPROVEMENTS

---

and 0% weed seed. Apply at a rate of 6-8 lbs. per 1000 sq.ft. No annual rye accepted under any conditions.

Label must be approved by University Landscape Architect and actual labels from bags should be given to OSU for both the seed and fertilizer.

**OARDC:** For areas with full sun exposure: use the current "Champion" mix prepared by the Oliger Seed Co. 1-330-724-4810 in Akron, Ohio. Substitute vendor is allowable as long as see mix matches the requirements set forth below or specific permission is granted by the OARDC Grounds Manager.

Special Mix: 50/50 Bluegrass/Perennial Rye: (4-5 lbs/1.000 sq.ft.)  
25% Brooklawn Kentucky Bluegrass  
25% Camas Kentucky Bluegrass  
15% Home Run perennial Ryegrass  
15% Paragon GLR Perennial Ryegrass  
10% Beacon Hard Fescue  
10% Kentucky Bluegrass

**OARDC:** For areas with less sun exposure: use the current "Champion" mix prepared by the Oliger Seed Co.

20% Intrigue Chewings Fescue  
15% Edgewood Creeping Red Fescue  
15% Zodiac Chewing Fescue  
15% Cardinal Creeping Red Fescue  
10% Beacon Hard Fescue  
10% Kentucky Bluegrass

### 32 92 19. SEEDING

- .1 SEEDING shall be done either between August 15 and October 15, or between March 15 and May 20. The early fall period is preferred. If seeding must take place after May or October and the turf requires a perennial rye and bluegrass mix, the seeding will be split. The perennial rye seed will be sown at the time scheduled and the bluegrass seed will be split, seeded over the same area in September.
  - .1.1 Seed: Seed with approved seed mix and rate (see 32 92 00.2 for seed selection); water if necessary for proper rate of germination. Areas that do not germinate must be reseeded and watered for establishment.
  - .1.2 Starter Fertilizer: Apply starter fertilizer prior to seeding, whether turf area is irrigated or non-irrigated. Apply at a rate of 1 lb. of nitrogen per 1000 sq.ft. Two weeks after seed germination another application of 1 lb. of nitrogen per 1000 sq.ft. should be applied to turf area.
  - .1.3 Mulch: Straw must be clean, free from seedbearing stalks or roots of noxious weeds, evenly distributed at an approximate thickness of two straws with no piles of straw. Any area that has had too much straw must be redone with the removal of the straw, touch up grading, if necessary, and the proper depth of straw applied.
  - .1.4 Cleanup: Clean off sidewalks of soil; sweep walks clean of straw, seed and fertilizer.
- .2 "MAINTENANCE: Seeded, sodded and planted areas shall be contractor maintained (including watering, mowing and weed control) until acceptance by the University. Total cover of planted areas shall be guaranteed by the contractor.

## DIVISION 32 – EXTERIOR IMPROVEMENTS

---

- .1.1: Begin maintenance immediately after each area is planted and continue until acceptable turf is established. Maintenance period shall be a minimum of 28 days or to final acceptance.
  - .1.2: When full maintenance period has not elapsed before the end of the planting season, or if turf is not fully established, continue maintenance during next planting season.
  - .1.3: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting and other operations. Roll, regrade and replant bare or eroded areas and remulch to produce a uniformly smooth turf.
  - .1.4: In areas where mulch has been disturbed by wind or maintenance operations, add new mulch. Anchor as required to prevent displacement.
  - .1.5: Provide and maintain temporary piping, hoses and turf watering equipment to convey water from sources. Keep turf uniformly moist to a depth of 4 inches.
  - .1.6: Schedule watering to prevent wilting, puddling, erosion and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas. Water turf daily for the first two weeks.
  - .1.7: Provide turf protection fencing around all newly seeded turf.
- .3 University Final Inspection and Acceptance:
- .3.1. Upon completion of the work and fulfillment of the requirements of the Section, 32 92 19, notify the University Landscape Architect in writing that the work is ready for final inspection. Request a definite date for final inspection.
  - .3.2. Notify the University Landscape Architect five (5) days prior to the requested final inspection date.
  - .3.3. Acceptance of seeded turf areas shall be based upon the following criteria:
    - a. Terms of the maintenance period, as defined in this paragraph have been executed. Seeded turf areas shall be healthy, uniform and a close stand of grass shall be established.
    - b. The seeded turf areas shall be free of weeds and surface irregularities.
    - c. In any 10 square foot area within the seeded turf, coverage shall exceed 95%.
    - d. Scattered bare spots shall not exceed an area 4 inches by 4 inches.
    - e. Grass shall not exceed 3" in height at time of acceptance.
  - .3.4. Acceptance of sodded turf areas shall be based on the following criteria:
    - a. Sodded turf shall be free of weeds and surface irregularities. All ends are butted tightly against each other and there are no overlapping joints. A clean edge will be made by using a mechanical sod cutter where sod abuts existing turf. Edge of sod must match the grade of existing turf. Sod will not be installed over existing turf, weeds or un-tilled soil.
    - b. Grass shall not exceed 3" in height at time of acceptance.

### 32 93 00. PLANTS

## DIVISION 32 – EXTERIOR IMPROVEMENTS

---

- .1 GROUND COVERS: must be weeded during the establishment period by the contractor to prevent perennial weeds from becoming established the University takes over the maintenance of the beds.
  - .1.1 A pre-emergence shall be applied at the time of planting to prevent the seeding in of new weeds.
  - .1.2 Perennial weeds must be sprayed with an herbicide to completely eradicate them from the bed.
  - .1.3. Spacing of the plant should be 3" - 6" o.c. to achieve coverage of the area during the first growing period. Planting should be watered and fertilized regularly to promote establishment prior to acceptance by the University.
- .2 SHRUBS: must be planted on appropriate spacing.
  - .2.1 All twine must be removed from the stems.
  - .2.2 Burlap must be pulled away from the stems and down 1/2 the ball.
  - .2.3 Nylon burlap must be totally removed.
  - .2.4 Backfill amendments (see trees .3.6)
  - .2.5 All shrubs must be evaluated and approved by or the University Landscape Architect prior to planting.
- .3 TREES: will be planted according to the planting detail in the appendix. No tree wrap is to be used. All mulch must be 2" away from the trunk of the tree. Mulch should be no thicker than 2". See 32 90 00.5 for type of mulch. The lip of the mound around the tree is to be no higher than 3". Forked trunks on trees are not acceptable; each tree must have one strong leader. Street trees must be limbed to 8 feet minimum.
  - .3.1 All trees that come in wire baskets must have the basket removed. All twine must be removed from the trunk of the tree.
  - .3.2 All trees that have burlap and are bound with twine, must have twine cut and the burlap pulled away from the trunk down to half of the ball.
  - .3.3 All trees and shrubs that are bound in nylon burlap must have the burlap totally removed.
  - .3.4 The stakes of all trees will be removed at the end of the guarantee period by the contractor.
  - .3.5 No tree will be planted within 10' of a building or overhead structure unless approved by the University Landscape Architect.
  - .3.6 Backfill amendments: Mix a starter fertilizer (high phosphorus, low nitrogen ratio) and terra-sorb (or equivalent) acrylamide copolymer for water retention; use product's rate of application per tree size.
  - .3.7 All trees must be watered in thoroughly until the acceptance by the University.
  - .3.8 All trees must be evaluated and approved by the University Landscape Architect prior to planting.

## **DIVISION 32 – EXTERIOR IMPROVEMENTS**

---

### **32 98 00. EXISTING TURF AND PLANT RESTORATION**

- .1 EXISTING TURF: Existing turf must be restored when compacted during construction. Repair any ruts or depressions left by equipment or storage of material. Remove topsoil containing foreign materials resulting from contractors operations including oil drippings, fuel spills, stone, gravel and other construction materials, and replace with new topsoil. Mow, dethatch, core aerate at a rate of 9 holes per square foot and rake existing turf. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides. Till stripped, bare and compacted areas to a soil depth of 6". Apply 1" Comtil over entire surface to be repaired. Slit seed using seed mix and rate appropriate to area (see section 32 92 00, Turf Grass Seed). Apply straw (see section 32 92 19, Seeding).
- .2 EXISTING SHRUBS: Existing shrubs within the construction area or staging area: replace or correctively prune if damaged during construction; prune to the height at the beginning of construction; weed/spray if weeds have grown up within the construction area and /or shrubbery.
- .3 EXISTING TREES: Existing trees: original grade maintained, no top fill greater than 2" from the original grade out of the drip line; minimal to no grading under the drip line.
- .4 RELEASE: Release of the restored area will be approved by the Superintendent of Grounds-Plant Material Section and the University Landscape Architect. The contractor will be recalled to provide a proper growing environment for the plant material.

---

END OF DIVISION 32 - EXTERIOR IMPROVEMENTS

**Table of Contents**

33 00 00.	UTILITIES .....	3
33 00 03.	GENERAL PROVISIONS .....	3
33 01 00.	OPERATION AND MAINTENANCE OF UTILITIES .....	7
33 01 70.	OPERATION AND MAINTENANCE OF ELECTRICAL UTILITIES .....	8
33 05 30	VENTILATION FANS .....	15
33 08 00.	COMMISSIONING OF UTILITIES.....	21
33 08 70.	COMMISSIONING OF ELECTRICAL UTILITIES.....	21
33 09 00.	INSTRUMENTATION AND CONTROL FOR UTILITIES.....	24
33 11 13	SITE WATER DISTRIBUTION.....	28
33 12 33.	WATER UTILITY METERING .....	36
33 32 25	DRAINAGE SYSTEMS .....	37
33 32 30	DRAINAGE PUMPS .....	41
33 40 00.	STORM DRAINAGE UTILITIES .....	45
33 51 13	UNDERGROUND NATURAL GAS LINES.....	46
33 51 33	NATURAL GAS UTILITY METERING.....	57
33 61 33.	HYDRONIC ENERGY DISTRIBUTION METERING .....	57
33 63 05	GENERAL PIPING PROVISIONS .....	62
33 63 10	COMMON WORK RESULTS FOR PIPING.....	72
33 63 10.2	PIPING GROUP 2 – CARBON STEEL - CHILLED WATER SUPPLY AND RETURN PIPE – CWS and CWR .....	97
33 63 10.20	PIPING GROUP 3 – CARBON STEEL - HIGH PRESSURE STEAM PIPE - HPS.....	98
33 63 10.90	PIPING GROUP 90 – TYPE 304L STAINLESS STEEL PIPE .....	99
33 63 10.94	PIPING GROUP 94 – TYPE 316L STAINLESS STEEL - HIGH PRESSURE AND PUMPED CONDENSATE PIPE – HPR AND PCR.....	100
33 63 13.94	UNDERGROUND CONDENSATE DISTRIBUTION PIPING .....	101
33 63 15	STEAM BLOWING.....	109
33 63 20	METERS AND GAUGES .....	115
33 63 25	PIPING SPECIALTIES.....	117
33 63 30	PIPE EXPANSION JOINTS .....	123
33 63 33	STEAM ENERGY DISTRIBUTION METERING .....	128
33 63 35	VALVES.....	134
33 63 35.2	VALVE GROUP 2: CHILLED WATER SUPPLY AND RETURN.....	142
33 63 35.3	VALVE GROUP 3: HIGH PRESSURE STEAM .....	143
33 63 35.10	VALVE GROUP 10: CONDENSATE RETURN.....	145
33 63 40	HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT .....	146
33 63 45	GASKETS.....	156
33 63 50	IDENTIFICATION FOR PIPING AND EQUIPMENT .....	157
33 63 55	PIPING INSULATION .....	160
33 70 00.	ELECTRICAL UTILITIES METERING .....	169



DIVISION 33 – UTILITIES

---

33 71 00.	ELECTRICAL UTILITY TRANSMISSION AND DISTRIBUTION .....	174
33 71 26.	TRANSMISSION AND DISTRIBUTION EQUIPMENT.....	174
33 71 49	MEDIUM VOLTAGE DISTRIBUTION SYSTEM .....	176
33 71 73.	ELECTRIC UTILITY SERVICES .....	184
33 72 00.	UTILITY SUBSTATIONS.....	192
33 72 33.	SUBSTATION CONTROL HOUSES AND ASSOCIATED FACILITIES.....	192
33 73 00.	UTILITY TRANSFORMERS.....	199
33 79 00.	SITE GROUNDING.....	203
33 79 19.	UTILITIES GROUNDING - ELECTRICAL.....	203
33 79 93.	SITE LIGHTNING PROTECTION.....	207

EXHIBITS	TITLE	Page
Fig 1	Electrical One Line	208
Fig 2	Standard Switch Configuration Two Feeders	209
Fig 3	Primary Switch Configurations Three Feeders	210
Fig 4	Primary Duct Bank Configurations	211
Fig 5	Electric Metering Connection Diagram	212
Fig 6	Typical DC Metering Panel Schematic Diagram	213
Fig 7	Typical DC Metering Panel (Front view)	213

**33 00 00. UTILITIES**

**33 00 03. GENERAL PROVISIONS**

**.1 APPLICATIONS:**

- .1.1 This Standard shall apply on all buildings within the Columbus campus of the Ohio State University.
- .1.2 This Standard shall apply for all temporary power for construction within the Columbus campus of the University.
- .1.3 This Standard may be applied for all other allied facilities and campuses of the University at various locations such as Lima, Mansfield, Marion, Newark, OARDC, Wooster, and other University properties.
- .1.4 This Standard may be applied to the Columbus campus University owned and occupied buildings powered from the local Utility that have the potential in the future of being supplied from the OSU Utility distribution system.
- .1.5 Requirements of this Standard are based on good engineering practice and provide a uniform and consistent basis for the design, construction, maintenance and operation of University Infrastructure and associated facilities.

Utilities maintains an Electrical Planning and Design Guide and a Chilled Water Building Connection Basis of Design that provides the technical basis for many of these requirements as they apply to the utility infrastructure on the OSU Columbus campus and should be consulted before recommending alternatives or any nonconformance.

**.2 DEFINITIONS**

- As-Built Drawings:** Drawings or computer files revised by the Contractor to show changes made during the construction process. (Ref; Ohio Department of Administrative Services, General Services Division, Ohio Facilities Construction Commission (OFCC), Standard Conditions of Contract for Construction).
- Contract Documents:** Collectively, the Drawings, Specifications, Addenda, Standard Conditions of Contract for Construction, Bid Form, Bid Guarantee, Contract Form and Attachments, Bond, Special Conditions, Wage Rates, Change Orders and Approved Shop Drawings, if any. (Ref; Ohio Department of Administrative Services, General Services Division, Ohio Facilities Construction Commission (OFCC), Standard Conditions of Contract for Construction).
- High Voltage:** Voltages higher than 35 kV (thirty five kilo-volts).
- Low Voltage:** Voltages less than 600V (six hundred volts).
- Medium Voltage:** Voltages less than 35 kV (thirty five kilo-volts) and higher than 600V (six hundred volts). 13.2 kV (thirteen-point-two kilo-volts) and 4,160V (four thousand one hundred sixty volts) are medium voltages.
- Owner:** The name 'owner' is prohibited language for Ohio State University projects. In all occurrences, delete 'owner' and insert 'University'.
- Record Drawings:** Drawings or computer files revised by the Architect/Engineer (A/E) to show changes made during the construction process, based on the As-Built Drawings furnished by the Contractor to the A/E. (Ref: Ohio Department of

	Administrative Services, General Services Division, Ohio Facilities Construction Commission (OFCC), Standard Conditions of Contract for Construction, Definitions D49, most current version).
Primary:	The Columbus Campus 13.2 kV Distribution system down to and including the Building Service Primary Select Switch.
Switched Primary:	Primary circuits that are served from the load side of Primary Select Switches that retain the characteristics of a service pair (i.e. Two independent feeds to a building or building complex).
Lateral:	A pair of cables tapped off the primary and carrying power to a building primary switch.
Load way:	A cable carrying power into a building, fed from a primary select switch at 13.2 kV.
Primary Service	The 13.2 kV service to a building or building complex inclusive of Primary Select Switch, load ways, Primary transformer with fuse and disconnect means. A pair of service drops from a pair of medium voltage feeders is required to provide a Primary Service connection.
Main Power System	The 138 kV Main Power Substation(s) inclusive of High Voltage (138 kV) connections, Main power Transformers, Busses, Capacitor banks and Feeder Circuit breakers.
AEP Bulk Power	The 138 kV portion of the Main Power Substation(s) inclusive of incoming 138 kV lines, 138 kV Circuit breakers and ancillary equipment such as Potential transformers, current transformers, Disconnect Switches, 138 kV busses, communications and Protective relaying. Note: see Figure 1 for a schematic representation of 13.2 kV distribution system
Service Connection:	Electrical: 13.2 kV distribution system drop to a facility Mechanical: Chilled water supply drop to a facility or a high pressure steam drop to a facility
University:	The Ohio State University.
Utilities:	Utilities Department, within the Facilities Operations and Development Division, at the Ohio State University.

### .3 ACRONYMS

AEIC:	Association of Edison Illuminating Companies (Codes and Standards)
AMP:	Ampere (unit of electrical current)
AGA:	American Gas Association.
B31.1:	ASME Power Piping Code (most current version)
ANSI:	American National Standards Institute (Codes and Standards)
AWG:	American Wire Gauge
AWWA:	American Water Works Association
BDS:	Building Design Standard of Ohio State University
BTU:	British Thermal Unit
CDF:	Controlled Density Fill
CAT:	Category
D:	Diameter
DAS:	Data Acquisition Software

## DIVISION 33 – UTILITIES

---

DWG:	Drawing
EEPROM:	Electrically Erasable Programmable Read Only Memory
EMT:	Electrical Metallic Tubing
EPR:	Ethylene Polypropylene Rubber (insulation)
F:	Fahrenheit
FDC:	Facilities Design and Construction Department, within the Facilities Operations and Development Division, at the Ohio State University
FOD:	Facilities Operations and Development Division, at the Ohio State University
FPS:	Feet per Second
HMI:	Human Machine Interface
Hi Pot:	High Potential (high voltage testing)
HR:	Hour
ICEA:	Insulated Cable Engineers Association (Codes and Standards)
IEEE:	Institute of Electrical and Electronics Engineers, Inc. (Codes and Standards)
ISA:	International Society of Automation
ISO:	International Standards Organization
KLBS:	Thousand Pounds
KCMIL:	Wire size unit, is the equivalent cross sectional area in thousands of circular mills. A circular mill (CMIL) is the area of a circle with a diameter of one thousandth (0.001) of an inch, (1 KCMIL = 1,000 CMIL).
kV:	Kilo-volt (thousands of volts)
kVA:	Kilo Volt-Amps (thousands of volt amps)
kW:	Kilo-watt, a rate of energy delivered or consumed.
kW-hr:	Kilo-watt hour, a cumulative sum of energy delivered or consumed.
LBS:	Pounds
LCD:	Liquid Crystal Display
LOTO:	Lock Out, Tag Out (procedure)
mA:	Milliampere
MCOV:	Maximum Continuous line-to-neutral Operating Voltage
MVA:	Mega Volt-Amps (millions of volt-amps)
NEC:	National Electrical Code, (Codes and Standards), plus version(s) as Code-applied within the State of Ohio, Ohio Building Code (OBC)
NEMA:	National Electrical Manufacturer's Association (Codes and Standards)
NESC:	National Electrical Safety Code (Codes and Standards)
NETA:	International Electrical Testing Association (Codes and Standards)
NFPA:	National Fire Protection Association (Codes and Standards)
NIST:	National Institute of Science and Technology (Codes and Standards)
NPT:	National Pipe Thread
OAC:	Ohio Administrative Code
OBC:	Ohio Building Code
OEM:	Original Equipment Manufacturer
O-&-M:	Operations and Maintenance manuals as published and provided by manufacturers and Contractors
ORC:	Ohio Revised Code
OSU:	Ohio State University
P&ID:	Process and Instrument Diagram
PILC:	Paper Insulated Lead Covered (cable and splices)

PSIG:	Pounds per Square Inch Gauge
PVC:	Polyvinyl Chloride
REF:	Reference
RFI:	Resettable Fault Interrupter (switch)
RTD:	Resistance Temperature Detector
RTU	Remote Terminal Unit
SF6:	Sulfur hexafluoride (gas-filled switch)
SS:	Stainless Steel
TCP/IP:	Transmission Control Protocol and Internet Protocol
TSG:	Technical Services Group, within the Facilities Design and Construction Department, within the Facilities Operations and Development Division, at the Ohio State University
TSP:	Twisted-Shielded Pair (of wires)
URL:	Upper reading Limit
W.G.C.:	Water Gauge Column
TSQ:	Twisted-Shielded Quad (of wires)
TTR:	Transformer Turns Ratio
UTHVS:	Utilities High Voltage Services (UTHVS), within the Utilities Department, within the Facilities Operations and Development Division, at the Ohio State University

- .4 SITE UTILITY IDENTIFICATION: The A/E must check with the Ohio Underground Utilities Protection Service (phone: 800-362-2764) to identify and locate all known utility lines in the construction area. Additionally they must comply with Section 153.64 of the Ohio Revised Code relative to underground utilities in relation to construction of public improvements.

**Commentary:** The Ohio State University became a member of the Ohio Underground Utilities Protection Service on October 17, 2016.

- .4.1 All bid documents for projects with any site work identified shall contain the following statement, to appear on the appropriate site plan sheet(s), as well as in the appropriate sections of the project specifications: “Contractor shall notify the Ohio Utilities Protection Service (toll free 800-362-2764) at least 48 hours, but no more than 10 working days prior to any excavating, fencing, planting, or other work that disturbs earth for the location of existing underground facilities. All other owners of underground utilities who are not current members of OUPS should be notified two working days in advance. The Ohio State University will not permit any site work to proceed until utility marking has been completed.”

- .5 COORDINATION OF DIVISIONS OF THE WORK: Extreme care is required in preparation of documents to assure no overlapping of the scope of work for the various contracts. Each contractor shall be required to perform excavation, trenching, and backfill for his installations. Materials and compaction of fill materials shall meet the requirements stipulated in Division 31, regardless of who performs this work; therefore, in Divisions 21, 22, 23, 26, 33, and 40, the requirements for earthwork may be best specified by making reference to Division 31. The reference should call attention to the fact that the paragraph regarding payment for laboratory service applies. Also see Facility Services-3.

- .6 PAYMENT OF FEES: City of Columbus Sanitary Sewer Tap Fees and System Capacity Charges shall be paid by the contractor doing the work. The contractor shall pay the fees to the city prior to commencing the work and shall provide to the University a written receipt as proof of payment. The Sanitary Sewer Capacity Charge is based on the size of the domestic water service line to the building as per the City of Columbus Division of Sewerage and Drainage Schedule of System Capacity Charges. The amount due is based on the scheduled fee at the time the connection is made. The A/E must check with the City of Columbus Division of Sewerage and Drainage to determine the tap fees and capacity charges and these costs shall be noted in the bid documents.
  - .6.1 No tap fees or system capacity charges are required for connection to the University water system. However, the details of connection must be arranged with the University Utilities Division of the Facilities Operations and Development.
  - .6.2 Connections with the City of Columbus water system are subject to tap fees and system capacity charges similar to the sanitary sewer system.
- .7 Standards for exterior domestic water piping, fire mains, hydrants and post indicator valves can be found in the Ohio State University Building Design Standard (OSU BDS) sections 33 11 13. Refer to the City of Columbus (COC) and Ohio Department of Transportation (ODOT) construction and materials specifications for standards not found in the OSU BDS. Refer to COC standard drawings for applicable materials and installation requirements for work within Franklin County and ODOT standard drawings for work outside Franklin County. Exterior soil and waste system University standards are described in OSU BDS section 22 10 05. Exterior gas piping requirements are described in OSU BDS 33 51 13. Division 22 provides standards for plumbing systems within buildings. OSU BDS section 23 20 07 provides requirements for underground pipeline conduit.
- .8 The A/E shall specify that the contractor shall provide advance notice of at least 5 days and an inspection window of at least 4-hours before covering buried equipment and pipelines with fill. If this notice is not given and if FOD Utilities requests, based on a lack of other documentation or approved inspections, the contractor shall remove or uncover such portions of the work as directed to allow FOD Utilities to complete inspections. The uncovering or removing of fill and the replacing of the cover and restoration of the parts removed shall be at the Contractor's expense.
- .9 RISK MITIGATION PLAN: When directed, the A/E shall develop a Risk Mitigation Plan and Construction Specifications that will minimize risks of construction activities to underground infrastructure and pedestrians. When active utility lines are at risk, The Risk Mitigation Plan shall require an Excavation Permit and a Disaster Preparedness Plan.
- .10 TUNNEL DESIGN: The A/E shall design for and specify station labels every 100 feet for each tunnel project. Station numbering shall be consistent with the University tunnel numbering system.

**33 01 00. OPERATION AND MAINTENANCE OF UTILITIES**

- .1 INTRODUCTION

- .1.1 To a large extent the success of any great institution depends on the strength and durability of its infrastructure. A key element of the University infrastructure is its Utilities. Utilities play a vital role in almost every aspect of the University experience, including (alphabetically) Academics, Athletics, Event Centers, Food Services, Hospitals, Housing, Medical Center, Recreational Sports, Research, Vivaria, and other allied institutions. The mission in Utilities is to provide a high standard of quality of service, and continuity of service, with a principal focus on public and employee safety. Recent increases in numbers and sizes of highly complex facilities, such as those serving the Medical Center plus various Research facilities, places even greater dependence upon safe and reliable Utilities.
- .1.2 The utility infrastructure performance relies on maintenance, equipment performance, and human performance.
- .1.3 Human performance relies on training, standards (design consistency) and reliable equipment (good maintenance, sound design).
- .1.4 Equipment performance relies on sound design, quality components and sound maintenance practices.
- .1.5 Good maintenance relies on sound planning, quality components, sound design and reliable human performance.
- .1.6 No element stands alone. No one element can be sustained without the others. No one element can compensate for the absence of another. This DIVISION 33 of the BDS sets forth unique requirements applied to address the equipment performance, human performance and maintenance needs of the Utilities infrastructure of the University. These requirements should be used in conjunction with the remainder of the BDS to arrive at a design and implementation that meets the full utility performance expectation of the University and its allied institutions.

33 01 70.

OPERATION AND MAINTENANCE OF ELECTRICAL UTILITIES

.1

SYSTEM DESIGN CRITERIA

- .1.1 The requirements and guidelines set forth in this Standard support meeting the basic design criteria in a manner consistent with the University's objectives for service continuity and safety. Life Safety and preservation of property and business operations are the two most important factors in the design of the electrical utility system. The practices and conventions referenced herein and applied throughout the design of the Medium Voltage Distribution System and its allied facilities are the product of an engineering process directed toward optimizing safe and reliable operations. Compliance with OSHA and National Electric Safety Code requirements is fundamental. Compliance to the National Electric Code is not a design requirement and shall be invoked only on a case by case basis, conformant to the Code applicability statements and where technically useful in obtaining Utilities' objectives for overall facility safety and reliability.
- .1.2 This Standard is the 'minimum' requirement. This Standard is not intended as a replacement for the many excellent electrical Codes or engineering texts and handbooks commonly in use, nor is it detailed enough to be a design manual.

- .1.3 General system design criteria are as follows:
  - .1.3.1 The main electrical system shall be designed such that a single Primary electrical power component outage shall result in prolonged outage to no more than one service connection.
  - .1.3.2 No service connection shall be designed or operated in a way that places the reliability of the Primary electrical power sources in jeopardy, or places the safety of the Public or University Staff in jeopardy.
  - .1.3.3 No single failure in the protection or control systems for critical main power system components shall result in total loss of component or system protection.
  - .1.3.4 No single failure of the control system shall result in loss of redundant systems or components.
  - .1.3.5 Equipment and circuit loading shall be kept within the ratings of the components that make up the system.
  - .1.3.6 System components shall be designed so as to make them maintainable and facilitate operating condition monitoring.
  - .1.3.7 All critical components shall be monitorable and testable.
  - .1.3.8 To the extent practicable, systems shall be designed to minimize operator and maintenance personnel disorientation and /or need for additional training because of unwarranted inconsistencies in operating, maintenance requirements or Human Machine Interface (HMI).
  - .1.3.9 Where appropriate, the design shall meet the requirements of the National Electric Safety Code (NESC) and other utility industry recognized Codes and Standards.
  - .1.3.10 Main electrical power system designs shall address both system reliability and component protection in a way that balances the need for continuity of service and protection of physical assets.
  - .1.3.11 No design shall contain features that present a risk to life safety, public or facilities personnel safety beyond what can be reasonably controlled by training, administrative safety procedures, Lock Out – Tag out (LOTO) and personal protective equipment.
  - .1.3.12 All components shall be Utility grade quality.
  
- .2 SYSTEM PROTECTION
  - .2.1 System Protection is the protection of the electrical power system. There are two classes of electrical protection: that which is designed to protect equipment or personnel from the potentially harmful effects of overloads or inadvertent grounding and that which is designed to limit the severity or extent of loss of power supply.
    - .2.1.1 Common requirements of the initial class are overload devices and ground fault isolators. These act to interrupt power before damage can occur. See DIVISION 26 sections for this class of devices for these types of applications.
    - .2.1.2 Common requirements of the latter class are fuses set to isolate failed transformers from the Primary electrical system, and



protective relays that act to isolate faulted portions of the Primary electrical system to allow the remainder to function normally.

- .2.1.2.1 As a general rule, Primary electrical system protective devices are applied to isolate to protect the supply rather than operate to protect the downstream component (failed device).
- .2.1.2.2 Fuses or electronic fuse emulation on gas (SF<sub>6</sub>) or vacuum switches used for the primary service drop are set to ride through transformer magnetization transients and load transients. They are not intended to provide overload protection for the transformer or downstream switchgear or bus-work. (Refer to DIVISION 26, for specific requirements concerning sizing of facility distribution system, arc flash, coordination study, load flow, and short circuit analysis.)
- .2.1.2.3 Primary circuit protection is designed to isolate faulted circuits from the main 13.2 kV supply bus. This protection is set to coordinate with the service drop protection and should be set to stay under the cable damage curves for faults. It provides little or no overload protection. In some instances Resettable fault Interrupters (RFIs) are applied in series or ahead of fuses in Primary circuits feeding building services. This is intended to afford Arc Flash reduction during switching operations and to aid in fault location. These devices do not provide selectivity or support coordination. RFIs applied in Primary Switches that develop a Switched Primary may be equipped with a relay protection package designed to coordinate with the Primary circuit protection
- .2.1.2.4 Major Primary electrical system components are provided with differential-type protection that is designed to isolate the faulted component in a very short time (less than 50 milliseconds). This limits damage to the components, the threat of collateral damage to other components in the area or upstream electrically from the faulted component. It also serves to limit the electrical voltage transient experienced by other power system components and loads. (Examples of component and equipment afforded such protection are: large transformers, buses, generators, very large motors and cable feeders that connect major busses).
- .2.1.2.5 Primary power system protective relay applications are designed so that no single failure of a protective relay or fuse will result in the total loss of ability to isolate the failed component. This involves the use of a diverse relay function such as coordinated time over-current relaying. These relays are applied to wait out the time the failed relay should have taken to initiate a trip and then trip. This

protection takes longer to act and generally results in less selectivity (more components are de-energized than the faulted component).

- .2.1.2.6 Three key attributes of the protection system are speed, selectivity and reliability. These must be factored into every primary electrical power sources and power supply protection scheme.
- .2.1.2.7 Testability and routine surveillance are key to assuring the reliability of the power supply protection. Protective relays must be testable in service without lifting wires. Because of this requirement, they shall be equipped with integral test plugs or external test switches. Modern solid-state microprocessor and multifunction relays are equipped with built-in diagnostics that aid greatly in performing periodic inspections. These features do not substitute for testing and calibration checks that force currents and apply voltages and develop output trip functions.
- .2.1.2.8 All Primary power supply protective relays should be surveyed quarterly and subjected to a full re-calibration and trip check on a nominal five-year interval.
- .2.1.2.9 Any changes to the Primary power supply, primary distribution or primary service connections must be in conformance with the above stated design and operating philosophy and shall not degrade the overall performance of the Primary system.

.3 A/E AND CONTRACTOR PROVISIONS

- .3.1 INFORMATION FOR DESIGN OF SYSTEM: During the initial planning conference, A/E shall consult with UTHVS and TSG regarding the sizing and configuration of the primary service. Refer to BDS, Part One - The Design Process, Processing the Work, paragraph 00015 Conferences, sub-paragraph .1, Initial Planning Conference, for the requirement that the A/E's Electrical Consultant shall attend the planning conference(s).
- .3.2 The A/E shall specify only Underwriter's Laboratories listed equipment, assemblies, and materials when such items are available and technically acceptable to the design. The equipment and materials shall be installed in accordance with its listing. Equipment and materials shall be selected from a pre-approved Manufacturer list, and subject to UTHVS approval (TSG consultation).
- .3.3 A/Es submitting proposals to provide electrical engineering, design or construction services shall be required to demonstrate adequate competency, and recent relevant work history. This requirement applies to the A/E's supervision and work force as well as to sub-A/Es, their supervision and work force. Work experience, personnel credentials and work references shall be submitted in writing at the request of UTHVS or TSG for their review and approval. This requirement applies to all sub-A/Es as well. The A/E shall be prohibited from working in electrical substations, the medium voltage power

- distribution system, the power plant, or related facilities unless they demonstrate they have established a verifiable record of safe work practices and training suitable for work around high and medium voltage equipment.
- .3.4 The A/E is responsible for addressing and resolving all review comments by UTHVS and TSG concerning primary power system design to the satisfaction of UTHVS and TSG.
  - .3.5 In conformance with the Primary Electrical Service Policy, [https://fod.osu.edu/sites/default/files/primary\\_electrical\\_service.pdf](https://fod.osu.edu/sites/default/files/primary_electrical_service.pdf) the connection to the Utility electrical system shall not be energized if these Standards are not met or if the design or A/E approved equipment or installation fails these Standards or inspections by Utilities High Voltage Services (UTHVS) and the required inspections by the appropriate State and Local Authorities having jurisdiction over those inspections.
  - .3.6 The A/E shall direct the contractor(s), through the construction documents, to meet the following requirements:
    - .3.6.1 The Contractor(s) and its sub-contractor(s) shall purchase only Underwriter's Laboratories listed equipment, assemblies, and materials when such items are available and technically acceptable to the design. The equipment and materials shall be installed in accordance with its listing. Equipment and materials shall be selected from a pre-approved Manufacturer list, and subject to UTHVS approval (TSG consultation).
    - .3.6.2 Contractors submitting proposals to provide electrical construction and installation services shall be required to demonstrate adequate competency, and recent relevant work history. This requirement applies to the Contractor's supervision and work force as well as to sub-contractors, their supervision and work force. Work experience, personnel credentials and work references shall be submitted in writing at the request of UTHVS or TSG for their review and approval. This requirement applies to all sub-contractors as well. The Contractor and sub-contractors shall be prohibited from working in electrical substations, the medium voltage power distribution system, the power plant, or related facilities unless they demonstrate they have established a verifiable record of safe work practices and training suitable for work around high and medium voltage equipment, and a verifiable record of quality of workmanship and reliability.
    - .3.6.3 In conformance with the Primary Electrical Service Policy, the connection to the Utility electrical system shall not be energized if these Standards are not met or if the purchased equipment or installation fails these Standards or inspections by Utilities High Voltage Services (UTHVS).
    - .3.6.5 Contractors shall conform their construction practices to the OSU Utilities Project Safety and Health Guide.

.4 CONFIGURATION MANAGEMENT

- .4.1 A/E's designs shall be submitted to and approved by UTHVS and TSG, before publication for Bid.
- .4.2 A/E's designs shall include related studies and reports. The A/E shall supply facility coordination studies, short circuit analysis, load flow studies, and arc flash analysis to UTHVS and TSG for approval. (See DIVISION 26 for specific requirements concerning sizing of facility Low Voltage distribution, arc flash, coordination study, load flow, and short circuit analysis.)
- .4.3 A/E's Construction Document Submittal: Drawings submitted for review and comment as "Construction Document" submittals shall be provided in full-size printed format for record as well as in native revisable format. The revisable format required for compatibility with the University CAD system is the current version of AutoCAD. This revisable format requirement is limited to main distribution substations, main feeders, power plants, and regional chiller plants. In such cases, the drawing format, content, numbering and conventions shall conform to the requirements of the University Utility drawing System and be coordinated with existing drawings maintained in that system. Where practical, the pre-existing drawings shall serve as the basis for the Associate's project drawings. Design drawings developed for the construction of Utility facilities shall conform to the numbering and classifications given in Section .4.4.8.
- .4.4 The A/E shall direct the contractor(s), through the construction documents, to meet the following requirements:
  - .4.4.1 Contractor's submittals shall include related studies and reports as they related to the installed equipment.
  - .4.4.2 Software: Component and system software, firmware and configuration files shall also be provided in hard copy and/or electronic media form as part of the "construction" package.
  - .4.4.3 As-Built Drawings: As the project progresses through the construction and commissioning process, an up to date marked up set of As-Built Drawings shall be kept at site in a secure location under the control of the electrical Contractor, prime Contractor or Commissioning Authority to serve as the as-built condition for the project. Mark-ups to these drawings shall include all changes to the original design as well as a record of all changes and additions made to the design by the construction Contractor to accommodate interferences and as found conditions. These mark-ups shall be performed by qualified personnel, be complete and reflect good drafting practice. At no time shall the University be without up to date marked-up drawings for the project. Usable and complete copies of project As-Built shall be made prior to removing the original marked-up drawings from site, and retained at site for use by the University engineering and maintenance personnel until the final Record Drawings can be issued and distributed for use.
  - .4.4.4 Record Drawings: At the completion of the project, these As-Built Drawings shall be submitted by the Contractor to the A/E for review and permanent incorporation onto project Record Drawings. These Record Drawings shall be provided within 90 days of project

completion to the University. The Record Drawings shall be delivered in full-size printed format, as well as electronic AUTOCAD format, most current version, for storage and use within the University CAD-based Archive system.

- .4.4.5 Software/Firmware As-Builts: TSG and UTHVS require that complete and up to date software and firmware, component configuration files, source code, including printed and published formats where applicable, shall be furnished by the contractor within 90 days of project completion, as a part of his final submittal for the project. This information shall be prepared specifically for each programmable or configurable component and system included in the project.
- .4.4.6 Labeling: The Contractor, at the time of installation, shall field-label all major power components. Equipment labels shall provide the name and function of the equipment as well as its power source. When the equipment is made up of two or more separately identifiable devices, sections or compartments; these too shall be individually labeled. Nomenclature used on the field-labels shall be consistent with that used on the Contract Documents, O&M documents and training materials. All field-labels shall be readable from a distance of three feet.
- .4.4.7 Control devices such as control switches, relays, displays and instruments shown on One Lines, schematics, interconnection wiring diagrams etc., shall be field-labeled with nomenclature consistent with that used on the Contract Documents.
- .4.4.8 The drawing numbering system shall follow drawing naming requirements. To find these requirements: click on the following link, choose the Utilities banner and click on Electronic Drawing Naming:  
<https://fod.osu.edu/resources>

## .5 TRAINING AND SUPPORT

- .5.1 OPERATOR TRAINING: Operator training for routine operation of systems or equipment shall be provided: The University on a case-by-case basis shall set Training requirements. Such training shall at a minimum include one full instructor-day, minimum 8-hours per shift, of on-site instruction for the daily operation of the system, to be attended by University's designated Operations personnel. All training shall be scheduled by the contractor in coordination with the University's FOD Training Officer, or his designated representatives.
- .5.2 ADDITIONAL TECHNICAL SUPPORT DURING WARRANTY: In addition to the warranty for labor and materials as specified in General Terms and Conditions: the contractor shall at the request of the University, provide additional technical support up to a maximum of two full person-days, minimum 16-hours, on-site support for the system during warranty. All support shall be at the request of the University's Director of Utilities or his designated representatives.

- .5.3 In addition to the above training for operation of equipment, Training for System Maintenance, shall include the OEM manufacturer’s standards for:
  - .5.3.1 OEM hardware tools and documentation
  - .5.3.2 OEM software tools and documentation
  - .5.3.4 OEM certificate of “Authorized Warranty Service Technician” or equivalent
  - .5.3.5 The training shall allow the University to perform all maintenance and inspection functions. The software tools shall perform on industry standard Windows-based laptop personal computers, using industry standard MS operating systems. The University shall agree on the location of the training.

**33 05 30 VENTILATION FANS**

PART 1 - GENERAL

.1 RELATED DOCUMENTS

- .1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

.2 DESCRIPTION OF WORK

- .2.1 Provide fans as scheduled on the drawings.

.3 SUBMITTALS: Submit the following to the University for approval.

- .3.1 Shop Drawings: Show fan layout, housing, materials, gauges, dimensions, weights, and installation details. Provide shop drawings indicating requirements for fan and accessories coordination with ventilation structures.
- .3.2 Product Data: Manufacturer's fan performance (data includes L/S, rpm, bhp, motor nameplate data, tip speed, outlet velocity and static pressure) and sound performance (data includes sound power level ratings by octave bands) as tested in accordance with AMCA Standards 210 and 300.
- .3.3 Fan Curves - Submit curves for all fans with system performance shown, and for +10% and +20% changes in fan rpm. Curves shall include plotted rpm, horsepower, CFM, static pressure and fan surge line.
- .3.4 Certified AMCA Ratings - Submit ratings for air and sound performance.
- .3.5 UL Listing - Submit listing specified.

.4 QUALITY ASSURANCE

- .4.1 Factory balance each fan statically and dynamically, and test run before shipment.
- .4.2 Fans shall operate quietly and without pulsation or vibration. Coordinate sound power level tests for each type fan at the factory in accordance with AMCA Standard 300.
- .4.3 The capacity shown in the fan schedule is the minimum air quantity the fan should deliver at the static pressure and rpm specified.
- .4.4 The resistances shown in the schedules are those required by the project, and do not include the internal and intake fan losses, integral outlet dampers, inlet

- screens, outlet velocity heads or drive losses. The fan manufacturer shall size and provide fan motor that compensates for all losses.
- .4.5 Factory performance test each fan assembled in or as part of apparatus specified to be performance tested. Test shall display scheduled performance characteristics, using certified, calibrated testing increments provided by the manufacturer of the apparatus.
  - .4.6 All fan performance ratings shall be based upon factory tests performed in strict accordance with AMCA Standard 210. All fans shall be certified by AMCA and carry its seal.
  - .4.7 Fan manufacturer shall check the moment of inertia ( $WR^2$ ) of the fan/impeller to be certain that the speed torque curve of the motor specified will accelerate the fan wheel to design speed without overload. Furnish larger motor, if required, and show revision on submittals.
  - .4.8 Fans shall not operate at speeds in excess of 80 percent of their true critical speeds.
  - .4.9 Provide propeller exhaust utility fan as manufactured by Greenheck Model SBC-3H36-50 or approved equal.
  - .4.10 Testing Requirements: The following factory tests are required:
    - .4.10.1 Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.
  - .4.11 UL Listed: All fans shall be UL705 listed for all electrical components

## PART 2 - PRODUCTS

### .1 FANS, GENERAL

- .1.1 General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.
- .1.2 Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.
  - .1.2.1 Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.
- .1.3 Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
  - .1.3.1 Service Factor: 1.4.
- .1.4 Belts: Oil-resistant, non-sparking, and non-static.
- .1.5 Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.

- .1.5.1 Fan Guard: OSHA expanded steel guards for personnel protection from rotating belts, pulleys and blades.
- .1.6 Shaft Bearings: Provide type indicated, having a median life "Rating Life" (AFBMA L (50) of 200,000 hrs, calculated in accordance with AFBMA Standard 9 for ball bearings and AFBMA Standard 11 for roller bearings.
- .1.7 Factory Finish: The following finishes are required:
  - .1.7.1 Sheet Metal Parts: Galvanized or aluminum as specified prior to final assembly.
  - .1.7.2 Exterior Surfaces: Galvanized or aluminum as specified.
- .1.8 Dampers: Dampers or shutters for fans shall be gravity type with parallel blade construction.
  - .1.8.1 Constructed of 16-gauge galvanized steel and incorporate a pre-punched channel style mounting frame. Damper corners shall be caulked and sealed and reinforced with die formed brackets and gussets.
  - .1.8.2 Jamb sections shall incorporate stainless spring steel side plates with resilient cellular cushions.
  - .1.8.3 Roll-formed blades are to incorporate tight seal gasketing and interlock when closed.
  - .1.8.4 Dampers are to be provided with self-lubricating nylon bearings.
  - .1.8.5 Damper shafts are to be cadmium plated steel, minimum 12-mm diameter.
- .1.9 Motors: Fan motors shall have the following basic construction features and characteristics:
  - .1.9.1 Torque Characteristics: Sufficient to accelerate the driven loads satisfactorily.
  - .1.9.2 Motor Sizes: Minimum sizes and electrical characteristics as indicated, if not indicated, large enough so that the driven load will not require the motor to operate in the service factor range.
  - .1.9.3 Temperature Rating: 60°C maximum temperature rise at 150°F (65°C) ambient for continuous duty at full load (Class F Insulation minimum).
  - .1.9.4 Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.
  - .1.9.5 Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design B. Provide permanent-split capacitor classification motors for shaft-mounted fans and capacitor start classification for belted fans.
  - .1.9.6 Bases: Adjustable.
  - .1.9.7 Bearings: The following features are required:
    - Ball or roller bearings with inner and outer shaft seals
    - Grease lubricated
    - Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor



- .1.9.8 Enclosure Type: The following features are required:
  - Totally enclosed motors where located in air stream
- .1.9.9 Overload protection: Built-in, automatic reset, thermal overload protection
- .1.9.10 Noise rating: Quiet
  - Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, and special features
  
- .1.10 Starters, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 48 Electrical Sections.
  
- .2 PROPELLER FANS
  - .2.1 General Description: Belt-driven propeller fans as indicated consisting of fan blades, hub, housing, orifice ring, motor, drive, and accessories. The fans shall be suited for the installed environment including ambient conditions of 150°F. Review drawing schedule for mounting orientation. Provide special construction necessary for horizontal unit installation. Special construction for horizontal mount units may include but are not limited to the following.
    - 2.1.1 Grooved shaft with snap rings
    - 2.1.2 Motor pulley retaining hardware
    - 2.1.3 Reinforcing angles on the fan panel
    - 2.1.4 Propeller retaining hardware
  
  - .2.2 Housings: Galvanized, sheet steel with flanged edges, and integral orifice ring.
  - .2.3 Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub. Factory set pitch angle of blades.
  - .2.4 Drive Assembly: Belt-driven.
  - .2.5 Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:
    - .2.5.1 Pulleys: Cast-iron, adjustable-pitch.
    - .2.5.2 Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - .2.5.3 Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
    - .2.5.4 Motor and Drive Assembly: Resiliently mounted to the housing.
  
  - .2.6 Accessories: The following accessories are required as indicated:
    - .2.6.1 Fan blade guard
    - .2.6.2 Belt Guards: Expanded metal with reinforced edges
    - .2.6.3 Gravity Shutters/Back draft Dampers: Gravity-type shutters with aluminum blades in steel frames
    - .2.6.4 Shutter and damper guard
    - .2.6.5 Power disconnect switch
    - .2.6.6 Thermostat controls (Range 0-150°F)
    - .2.6.7 Switch controls
    - .2.6.8 Weather hoods
    - .2.6.9 Wall collars

- .2.6.10 Motor side guards
      - .2.6.11 Bird screens
    - .2.7 Fan housings and brackets shall be factory painted.
    - .2.8 Subject to compliance with the specifications and ratings requirements, provide propeller supply and exhaust wall fan as manufactured by Greenheck Model SBC-3H36 or approved equal.
  - .3 UPBLAST PROPELLER EXHAUST FANS
    - .3.1 General Description: Spun aluminum centrifugal belt driven up-blast exhaust fan with aluminum fan wheel and leak proof aluminum housing.
    - .3.2 Wind Band, Fan Housing, and Base: Reinforced and braced one piece heavy gauge spun aluminum, rain trough, motor and drive assembly, and fan wheel.
    - .3.3 Fan Wheel: Replaceable, aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
    - .3.4 Belt Drives:
      - .3.4.1 Resiliently mounted to housing.
      - .3.4.2 Weatherproof housing of same material as fan housing.
      - .3.4.3 Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
      - .3.4.4 Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow-block-type ball bearings.
      - .3.4.5 Pulleys: Cast-iron, adjustable-pitch motor pulley.
      - .3.4.6 Motor Mount: On outside of fan cabinet in separate compartment, adjustable base for belt tensioning. Factory mounted and wired NEMA 4 disconnect switch.
    - .3.5 Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch- (40-mm) wood nailer. Size as required to suit opening and fan base.
      - .3.5.1 Configuration: Self-flashing with built-in cant, with mounting flange.
      - .3.5.2 Overall Height: 12 inches (300 mm).
      - .3.5.3 Burglar Bars: 5/8-inch- (16-mm-) thick steel bars welded in place to form 6-inch- (150-mm) squares.
    - .3.6 Subject to compliance with the specifications and ratings requirements, provide Up-blast exhaust fan as manufactured by Greenheck Model CUBE or approved equal.

### PART 3 – EXECUTION

#### .1 EXAMINATION

- .1.1 Examine ventilation structures, areas and conditions, for compliance with requirements for installation tolerances, and other conditions affecting performance of fans.
- .1.2 Do not proceed until unsatisfactory conditions have been corrected.
- .1.3 Inspect combination fire smoke dampers in accordance with NFPA.

#### .2 INSTALLATION, GENERAL

- .2.1 Install fans level and plumb, in accordance with manufacturer's written instructions. Support units as described below, using the vibration control devices indicated.
  - .2.2 Arrange installation of units to provide access space around fans for service and maintenance as indicated but in no case less than that recommended by manufacturer.
  - .2.3 Adjust and balance fans for the specified airflow.
  - .2.4 Install combination fire smoke damper in accordance with the Manufacturer's instructions and listing requirements.
- .3 CONNECTIONS
- .3.1 Electrical Connections: The following requirements apply:
    - .3.1.1 Electrical power wiring is specified in Division 48 Electrical Sections.
    - .3.1.2 Automatic control wiring and interlock wiring shall be installed as shown on the drawings and as specified in Division 48 Electrical Sections.
    - .3.1.3 Grounding: Connect unit components to ground in accordance with the National Electrical Code.
  - .3.2 Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
    - .3.2.1 Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 48 Electrical Sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- .4 COMMISSIONING
- .4.1 Final Checks Before Start-Up: Perform the following operations and checks before start-up:
    - .4.1.1 Remove shipping blocking and bracing.
    - .4.1.2 Verify unit is secure on mountings and supporting devices, and that connections for electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
    - .4.1.3 Perform cleaning and adjusting specified in this Section.
    - .4.1.4 Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
    - .4.1.5 Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants when required.
  - .4.2 Starting procedures for fans:
    - .4.2.1 Energize motor; verify proper operation of motor, drive system, and fan blades. Adjust fan to indicated RPM.
      - .4.2.1.1 Replace fan and motor pulleys as required to achieve design conditions.

- .4.2.2 Measure and record motor electrical values for voltage and amperage.
- .4.3 Shut unit down and reconnect automatic control operators.

**33 08 00. COMMISSIONING OF UTILITIES**

**33 08 70. COMMISSIONING OF ELECTRICAL UTILITIES**

**.1 TESTS, INSPECTIONS AND ACCEPTANCE**

.1.1 Factory Testing: Factory testing for major equipment and integrated systems shall demonstrate design compliance to procurement and functional specifications. It shall be conducted to appropriate industry Standards and include third party testing and verification. The option for University acceptance by participation in the testing or through a review of the testing results shall be made available with a minimum of two weeks written notice to planned commencement of testing.

**.1.2 Installation Quality Control Testing**

.1.2.1 The contractor shall supply appropriate technically competent support to monitor workmanship and completeness. This shall involve in-line work inspection or audit inspection with rigorous corrective action, follow up and closure on non-conforming work products and methods. Tests and inspections shall include compliance to OSU Standards, and compliance to good industry practices. Instrument calibration and set point verification shall be included in the contractors test and inspection planning and execution.

.1.2.2 The contractor shall supply appropriate technically competent support to test and inspect installations for fitness for service in accordance with NETA guidelines.

.1.2.3 Testing shall be performed to demonstrate fitness for service of all components. A representative from UTHVS shall witness the testing. Copies of test results shall be provided to UTHVS and Technical Services Group through the OSU Project Manager.

**.1.3 Post Installation Testing**

.1.3.1 The contractor shall supply appropriate technically competent support to conduct thorough pre-operational testing of all installed systems and components for all modes of operation in accordance with NETA guidelines. Testing shall include equipment controls, protective relays and safety interlocks.

.1.3.2 System Functional Testing: All systems shall be tested to demonstrate their ability to function as required over the full limits of their normal operational range and for any emergency range as called for in the system design. This testing shall be conducted with the systems and associated equipment installed and operating in their normal mounted orientation, settings and conditions of power supply and environment. This testing may be conducted in an

integrated fashion with all system interfaced as designed or may be done piecemeal (overlapping) in a manner that demonstrates acceptable functionality of all interfaces, shared functions and dependencies.

- .1.3.3 Interlock verification testing: Once all construction has been completed and all system installation and construction testing completed, the University or their appointed agent shall conduct testing designed to validate the proper operation of all system permissives, trips, critical sequences, operator HMI functions and annunciations.
- .1.4 Certification Process: The University requires all test reports and records as well as individual certifications of any and all test authorities, the manufacturer or independent testing agencies be provided for review and acceptance. These records, along with supporting documents showing acceptable resolution of open items, test discrepancies, failures and repair, retesting etc., will serve as the basis for certifying equipment for service by the University.
- .1.5 University Acceptance Process: The University, as a recognized authority for the certification of systems and facilities for safe and conformant operation, is obligated to follow due process and demonstrate due diligence in their review and acceptance of all processes relating to quality, completeness and conformance to applicable Codes and Standards. University acceptance will be granted only after the certification process has been completed to the University's satisfaction and all documentation has been received, reviewed and accepted.
  - .1.5.1 Tests must be conducted in accordance with University requirements and shall be witnessed by representative(s) of UTHVS.
  - .1.5.2 Medium and low voltage cable testing shall comply with NETA and Association of Edison Illuminating Companies (AEIC) guidelines with the following exceptions:
    - .1.5.2.1 The University deviates from the Industry Standard of 64 kV and 96 kV at 133% cable insulation level due to destructive nature of this testing, field experience and the potential for cumulative damage.
    - .1.5.2.2 Hi-pot testing on 133% EPR insulated 13,200 volt system cable shall be a 42,000 volt DC High Pot performed by an approved test instrument witnessed by UTHVS. The 42,000 volt High Pot test shall be applied in 7,000 volt intervals of one-minute duration with a 5-minute sustained interval at 42,000 volts. High Pot testing of existing installed primary cables is limited under normal conditions to 10,000 volts. This 10,000 volt DC High Pot is applied gradually with a sustained duration at 10,000 volts for five minutes. The 42,000 volt test shall only be done after pulling, termination and splicing of new cables, but before splicing to the existing cables. A maximum of 10,000 volts DC high pot test

shall be applied for all installations after splicing to existing cable.

.1.5.2.3 Hi-pot testing on shielded 133% EPR insulated 4,160 volt system cable shall be a 28,000 volt DC High Pot performed by an approved test instrument witnessed by UTHVS. The 28,000 volt High Pot test is applied in 7,000 volt intervals of one-minute duration with a 5 minute sustained interval at 28,000 volts. High Pot testing of existing installed primary cables is limited under normal conditions to 19,000 volts. This 19,000 volt DC High Pot is applied gradually with a sustained duration at 19,000 volts for five minutes. The above limits apply to cables without the presence of a surge suppressor.

.1.5.2.4 Hi-pot testing for 600 volt circuits may be elevated to a maximum 2,500 VDC 1 minute duration for certain critical control components as identified by UTHVS on a case-by-case basis.

.1.5.3 Primary transformer and switchgear testing shall be conducted per NETA standards and witnessed by UTHVS. The tests shall be performed after installation of the transformer and switchgear.

.2 INDEPENDENT VERIFICATION

.2.1 The Commissioning agent shall act independently of the Construction contractor. The Commissioning agent may report to OSU project administrative and management staff or to the University Utility technical, administrative or management staff.

.2.2 The Commissioning agent may direct the construction contractor in the execution of critical aspects of the construction work scope and may, if authorized by Utilities energize or otherwise operate equipment and coordinate checkout, and coordinate commissioning activities such as instrument calibration and set point verification with equipment vendors directly.

.2.3 The Commissioning agent may reject construction contractor work for quality related reasons, and delay commissioning activity for incompleteness or lack of documentation.

.2.4 All Construction contractor conducted testing is subject to review and approval by the Commissioning agent.

.2.5 For projects requiring coordination of activities with an outside Utility, the Commissioning agent may be called upon to establish liaison and coordinate testing and checkout activity

.2.6 The Commissioning agent may be called upon to coordinate commissioning activity with the testing and commissioning activity of equipment manufacturers.

.2.7 All Commissioning activities shall be conducted in conformance and in support of the UTILITIES ELECTRICAL PROJECT SAFETY AND HEALTH GUIDE

**33 09 00. INSTRUMENTATION AND CONTROL FOR UTILITIES**

.1 General

This section addresses the control of major substation and distribution system electrical equipment such as switchgear, large power transformers and auxiliary support systems and equipment such as station battery systems, automatic transfer controls medium and low voltage motor control centers and transfer switches. The requirements contained in this section are to be used in conjunction with the requirements of other BDS DIV 33 and DIV 48 sections giving detail requirements relating to specific equipment and systems and their wiring and physical installation. Included in this section are requirements for controls using solid state and electromechanical relays, Programmable Logic controllers, motor starters, transfer switches, medium and low voltage switchgear, custom manufactured package systems, 125 v DC systems, power transformers of all sizes.

This section addresses the principal design criteria for the control of this equipment. The instrumentation referred to in this section is the power instrumentation required for the operation, testing and maintenance of this equipment such as ammeters, voltmeters, indicator lights, current transformers, potential transformers, shunts, meters, data acquisition systems, etc.

.2 Operability

Controls shall be designed to address the range of normal and emergency service requirements relating to the equipment and systems being controlled.

If controls are limited to manually initiated control functions, they should conform closely to conventions and practices widely used elsewhere for similar systems and equipment. Instrumentation needs to be present (at or near the control location) to assist the operator in determining the effectiveness of the control actions taken.

If the controls are automatic, they should contain features that provide status on the controls, the process and or parameters being controlled. These features should not depend on the same instruments providing the control variable inputs to the automation. Where automation has been applied to supplant manual control, the capability of some basic level of manual override should be provided along with the means for the operator to assess the situation and receive feedback on any manual operations undertaken ( example: and E stop with indication).

.3 Maintainability

Controls should be designed to facilitate planned maintenance for the systems and equipment being controlled. An example of this would be the inclusion of a manual control station to facilitate draining or filling operations or system post maintenance startup.

Automatic controls should be provided with information relating to the availability of system equipment when it has been removed from service for maintenance.

LOTO considerations relating to local power disconnects, power source lock-out, etc. must be accommodated.

.4 Constructability

Controls must be designed in conformance with the physical constraints of the facility. Control stations, cabinets, panels and compartments must be designed to facilitate cable access and provide adequate areas for orderly field cable marshalling and termination. Since the standards require the use of multi-conductor color coded jacketed and labeled cables with wire sizes in the AWG 10 to 14 for control conductors and AWG 16 for some instrumentation cables. Cable management requires careful planning and design.

.5 Testability

Controls need to be designed to facilitate planned preoperational and post maintenance testing for the systems and equipment being controlled. This may mean designing the controls with build in test modes of operation, or it may simply involve designing the controls to facilitate LOTO depending on system complexity and the various types of testing to be accommodated. Automatic controls should be provided with information relating to the availability of system equipment when it has been removed from service for testing.

.6 Human Factors

.6.1 Accessibility

Control stations need to be located where they can be conveniently reached and where they will not be in the way of routine or planned maintenance. Mounting control stations on equipment or in areas where access could be restricted because of ambient noise, high temperature or a higher than normal risk of steam or water leaks should be avoided.

.6.2 Lighting

Control stations need to have lighting adequate to support the operator's actions planned as well as sufficient access and egress lighting. Where task lighting cannot be supplied at high enough levels to accommodate operator needs, displays should be designed with back lighting or the control station should have its own source of task illumination.

.7 Human Machine Interface

.7.1 Type

The HMI selected should be appropriate to the task being performed. Hard wired controls for simple control actions, touch screens for more complex tasks and where visual or process displays would be helpful, analog displays for displaying rapidly changing parameters, digital where slow moving parameters are involved, where there is a wide range in the variable, or where precision is needed.

.7.2 Information displayed

The information displayed at a control station should be compatible with and adequate for the control actions planned for the station. Information displayed should be organized in a logical manner in relation to the control devices. Clutter should be avoided.

.7.3 Controls available.

Control devices available at a control station should be limited to what is required for the intended operations. Main or frequently used controls should be located centrally within the easiest reach of the operator. Less frequently used control should be positioned in their own functional grouping, out of the



central control area. Some controls that are not intended for normal control operations such as E-stops, or devices that would cause serious disruption if inadvertently operated should be placed in an accessible location but away from the more frequented areas of the control station. Functional grouping of controls is preferred. Clutter should be avoided. Guards should be provided or the “two independent action” rule should be employed where inadvertent operation could have grave repercussions.

.8 Environment

.8.1 Temperature, Humidity

Apply control components and locate control stations where they will not be exposed to adverse ambient temperatures, humidity and dew point cycling if at all possible. Enclosures should be designed with cabinet heaters for high humidity environments and should have a NEMA enclosure design consistent with the environment.

.8.2 Water hazards

Where water hazards could exist, control station equipment should be water tight or resistant. Care must be taken to insure that cable access is from below or low to the side. Where moisture intrusion is considered a risk, the control cabinet should be equipped with a bottom drain point that is screened to exclude insects and rodents.

.8.3 Proximate hazards

Locate control stations only where there is minimal risk of exposure to proximal hazards such as steam leaks, rupture diaphragms, safety valves, electrical Arc Flash, falling or tripping. Access to control stations should not involve climbing or the use of any temporary structures or scaffolding.

.9 FMEA

.9.1 Design practices

The design of the controls should observe to the extent practicable established and standardized control practices to benefit from past experience and lessons learned. The application of control components should be standardized around a limited set of approved components and manufacturer product lines to simplify spare parts stocking and training. Control circuit designs should be replicate between similar pieces of electrical power equipment and between similar systems.

.9.2 Failure modes

Control circuit failure modes should be identified and evaluated. Predominant failure modes should be accommodated by designing adequate annunciation and or indication to assure that the operator is aware of the failure and can take appropriate operator action. The impact of individual component failures should be minimized by applying the component in a manner so that the dominant failure mechanism would have the least significant impact on the system operation or potential for equipment damage.

Power dependencies should be identified and evaluated. Power sources should be selected to conform to the overall power dependencies of the prime movers in the system. The choice of control voltage should be based on

the characteristics of the control power sources available. Battery-backed 125 vdc is the most reliable source but designs powered from battery-backed 125 vdc should be energized to actuate, normally de-energized and be capable of being de-energized with critical systems in operation without the controlled system tripping. 125 vdc is the preferred source for electromechanical controls that must operate under blackout conditions and when system ac power is lost.

120 vac inverter backed control is the preferred power for electronic controls and instrumentation that must remain in service independent of the availability of system ac power. Inverter use should be restricted to this type of load and under no condition should an inverted backed ac source power motors or load with significant startup transients with the possible exception of switching type power supplies. Inverter sources are inherently current limiting, so the exposure of these circuits to shorts or grounds is a concern. This can be mitigated somewhat by providing a solid state transfer switch to an alternate source of ac with great fault support capacity. If electromechanical control devices such as relays and solenoids are powered off an inverter backed source, coil suppression is recommended.

Diesel-backed ac is the preferred source for controls that can sustain a momentary or short term loss of ac power and still function acceptably once power is restored. In the case of Emergency Diesel Generator power, restoration usually occurs in around ten (10) seconds. In the case of Standby generators, restoration may take as long as a minute or more.

.9.3 System effects

The system effects of a control system or component failure need to be assessed and addressed in the control design. Control failure modes must be compatible with system and component preferred failure states. A fail-closed, air-operated valve will generally require a solenoid and control circuit design where a solenoid coil or control power failure will result in the valve closure as well. A circuit breaker control which is designed to open and close the breaker is generally designed to fail as is. Safety considerations are another factor to be considered in control design. A failure in the trip circuit of a circuit breaker should remove power to both the close and trip portions of the breaker control circuits. This is a useful safety feature to avoid the possibility of closing a breaker whose trip circuit has already failed. Likewise, powering the closed indication of a circuit breaker by having the closed indicator light powered from the trip circuit through the trip coil of the breaker insures that the loss of closed indication on breaker closing will alert the operator to a possible abnormal situation with the breaker.

.9.4 Situational awareness

Particular care must be taken to insure that the instrumentation provided with controls provides adequate situational awareness for the operator to assess the effectiveness of automatic controls and to monitor manual control actions. Instruments and displays provided for monitoring the condition of the controlled system generally should not share signals with the instruments

controlling the system. As a general rule instrumentation that the automatic control function relies upon for its control action should be independent of the instrumentation relied upon to determine effectiveness of the automatic controls or depended upon to take manual control action.

.9.5 Recovery and use of lower tier controls

It is customary to provide echelon control to complex systems. Echelon control involves applying controls in layers. A system may have a master control that provides system level commands from a system operator or automatic dispatch control. This Master control may control only that one system or a variety of systems to coordinate their individual automatic operations. A system then may have subsystems that have their own automation and so on. Each of these layers may have both automatic and manual control modes.

As a general rule, a system or group of systems that share an echelon control architecture should have their controls designed to allow higher echelon automation to automatically detect the loss of lower echelon automation and take appropriate compensatory action to address system control needs including operator situational awareness and appropriate adjustment of lower tier operating modes, set points and limits.

Echelon controls should not be applied where loss of a subsystem's automation will result in a wholesale loss of system automation and wholesale reversion to manual control. Loss of automatic control at any level should always be readily recoverable by skilled operator action or result in placing the subsystem in a safe condition or operational mode with minimum disruption to the remainder of the control system.

**33 11 13 SITE WATER DISTRIBUTION**

**PART 1 – GENERAL DESCRIPTION**

- .1 This OSU Building Design Standard includes guidance for project A/E's on:
  - .1.1 Pipe, fittings and accessories for site water line including domestic water line and fire protection water line.
  - .1.2 Installing valves of type and size that the A/E shows on their project plans.
  - .1.3 OSU Fire Hydrants are per City of Columbus CMS Item 809.02 except where stated herein.
  - .1.4 Water line pressure testing.
  - .1.5 Disinfection of potable water distribution system.
  - .1.6 Testing and reporting results.
  
- .2 REFERENCES
  - .2.1 City of Columbus, Construction and Material Specifications, Item 800 Water Supply and Distribution, 2012 Edition
  - .2.2 AWWA B300 - Standard for Hypochlorites
  - .2.3 AWWA B301 - Standard for Liquid Chlorine
  - .2.4 AWWA C651 - Standard for Disinfecting Water Mains

- .2.5 National Fire Protection Association (NFPA) Standards 13, 24, and 25
- .3 SUBMITTALS
  - .3.1 Specify that the Contractor shall record actual locations of piping mains, valves, connections, thrust restraints and invert elevations.
  - .3.2 Specify that the Contractor shall certify that products provided meet or exceed the contract requirements.
  - .3.3 Specify that the Contractor shall submit product data on pipe materials, pipe fittings, valves, valve boxes, indicator posts, hot taps, fire hydrants, utility marking tape, backfill, and accessories.
  - .3.4 Test report:
    - .3.4.1 The A/E shall specify that the Contractor must provide test report with water at 150 psi pressure in accordance with AWWA procedures.
    - .3.4.2 Test Reports shall indicate results comparative to specified requirements.
    - .3.4.3 Certificate: Specify that the Contractor shall provide written certification of the cleanliness and sterilization of the water distribution system meets or exceed AWWA requirements. Specify that the Contractor shall submit bacteria test results to the A/E and the University prior to the water line being energized for service.
- .4 QUALITY ASSURANCE
  - .4.1 New domestic cold water utility piping shall not be designed to be routed through campus tunnels or through campus facilities. If no other reasonable alternative exists, routing the underground domestic cold water utility through a tunnel or through a campus facility requires a design variance submitted to the University Engineer. Any exposed domestic cold water pipe must be designed with restraints to account for thrust forces. The project designing and installing the exposed domestic cold water line shall provide third party inspection on the installed water line prior to the water line being energized for testing.
  - .4.2 Specify that the work shall be in accordance with the plans.
  - .4.3 Specify that the Contractor shall deliver and store material in shipping containers with labeling in place. The Construction Manager and A/E shall inspect on site materials for conformance prior to installation by the Contractor. Materials that do not conform to project and OSU Building Design Standards will not be allowed to be installed.
  - .4.4 Specify that the Contractor shall use a Water Treatment Company specializing in disinfecting potable water systems with a minimum of three (3) years' experience. If a Water Treatment Company is not going to be used by the Contractor, then the Contractor shall submit their qualifications and experience for disinfecting potable water systems.
  - .4.5 Specify that the Contractor's Water Testing Company specializing in testing potable water systems is certified by the State of Ohio. The Contractor shall submit bacteriologist's signature and authority associated with the water testing.

- .4.6 Specify that OSU Utilities is the Authority Having Jurisdiction (AHJ) over domestic cold water lines installed on Columbus Campus. Specify that The State of Ohio Fire Marshall is the State's AHJ for underground fire water lines that provide fire water to campus fire hydrants and facilities. OSU Utilities and The State of Ohio Fire Marshall will inspect and authorize water service if the installation meets the appropriate standards and no substandard practices, workmanship or non-conformant conditions are discovered, the water system is deemed safe for public consumption, and the A/E has provided their final signed and stamped by a State of Ohio Professional Engineer (Ohio PE) inspection results and determined that the installation meets or exceeds the A/E's design.
  - .4.7 Columbus Campus domestic cold water pressure is not regulated by OSU Utilities. The water is provided to OSU's Columbus Campus from the City of Columbus' water distribution system. The site, the building fire and plumbing systems designers for the A/E team are advised that domestic cold water pressure for campus fire and domestic water services will vary between 80 psig to 120 psig with demand, time of day, maintenance, outages, and other distribution system factors. The site water system piping shall be designed for a 120 psig maximum operating pressure and account for the range of operating pressures in the design. Building system pressure requirements shall be coordinated by the A/E Team. Any required pressure reduction will be within the building system.
  - .4.8 OSU Utilities maintains and updates a domestic cold water model for Columbus Campus water demand. Domestic cold water system site pipe sizing and building system water demands shall be reviewed and coordinated with OSU Utilities. The project team shall submit a completed Utilities request form for new and modified domestic cold water services. The form can be downloaded from the website by clicking on the following link, selecting the Utilities banner and choosing 'Utilities Request – New or Change':  
<https://fod.osu.edu/resources>
  - .4.9 In some cases OSU property is served by City of Columbus water lines and not OSU water lines. If that is the case, the A/E shall specify that the installing Contractor be authorized and have licensing approval to work on City of Columbus water line systems. This is in accordance with Columbus City Code 1103.02 and 1103.06 to perform work on City of Columbus water lines, including water service lines and taps.
- .5 PROJECT RECORD DOCUMENTS
- .5.1 Specify that the Contractor is responsible for maintaining accurate and up-to-date red line prints on the project site. The red-line prints shall show the as-built conditions of the water line. The Construction Manager and A/E shall regularly inspect and verify red-line prints for accuracy.
  - .5.2 Specify that the contractor shall notify OSU Campus Surveyor to have the water line surveyed (for OSU archive information) prior to backfilling the water piping. If the water piping is backfilled prior to survey, the contractor shall uncover piping at the Contractor's expense to allow for OSU survey.

- .5.3 Specify that the Disinfection report contain the following minimum amount of information:
  - .5.3.1 Type and form of disinfectant used
  - .5.3.2 Date and time of disinfectant injection start and time of completion
  - .5.3.3 Test locations
  - .5.3.4 Initial and 24-hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested
  - .5.3.5 Date and time of flushing start and completion
  - .5.3.6 Disinfectant residual after flushing in ppm for each outlet tested
  
- .5.4 Specify that the Bacteriological report contain the following minimum amount of information:
  - .5.4.1 Date issued, project name, and testing laboratory name, address, and telephone number.
  - .5.4.2 Time and date of water sample collection.
  - .5.4.3 Name of person collecting samples.
  - .5.4.4 Test locations.
  - .5.4.5 Initial and 24-hour disinfectant residuals in ppm for each outlet tested.
  - .5.4.6 Coliform bacteria test results for each outlet tested.
  - .5.4.7 Certification that water conforms, or fails to conform, to bacterial standards of the AWWA.

PART 2 - PRODUCTS

.1 MATERIALS

.1.1 WATER SERVICE CONNECTIONS 3-INCH AND LARGER

.1.1.1 Material

- .1.1.1.1 Ductile iron pipe for 3-inch and larger up to the meter inlet.
- .1.1.1.2 Marked from the factory with the words: DUCTILE IRON.
- .1.1.1.3 Specify pipe with a bituminous-coated cement lining that complies with AWWA C104 Specifications and an outside coating of bitumastic-enamel or approved equal.
- .1.1.1.4 Provide ductile iron pipe cast, cleaned, cement lined, coated, tested, and certified at a single manufacturing facility with all manufacturing units contiguous to one another.
- .1.1.1.5 Gauge full from the end of the spigot to two feet from the flare of the bell ten (10) percent of the ductile iron pipe supplied to the project.
- .1.1.1.6 Corrosion Control: OSU Utilities requires polyethylene encasement in accordance with AWWA C105 on buried ductile iron pipe, fittings, and accessories.
- .1.1.1.7 Material physical properties and wall thicknesses shall be:

Hardness	Rockwell B-90 maximum
Yield Strength	42,000 psi minimum
Tensile strength	60,000 psi minimum

Elongation in 2 inch	10% minimum	
Nominal Size	Class	Wall Thickness
3 inch	53	0.31 inch
4 inch	53	0.32 inch
6 inch	53	0.34 inch
8 inch	53	0.36 inch
10 inch	53	0.38 inch
12 inch	54	0.43 inch
16 inch	54	0.46 inch
20 inch	54	0.48 inch

.1.1.2 VALVES AND APPURTENANCES:

.1.1.2.1 Valves 3-inch and greater shall be specified as Gate Valves in accordance with item 802 of the City of Columbus' Construction and Material Specifications.

.1.1.2.2 Valves 2-inch and smaller shall be curb stop type or a 2-inch gate valve.

.1.1.2.3 For 20-inch valves and larger, specify and design on the plans 6-inch bypass piping and valves across each 20-inch valve.

.1.1.2.4 Specify valve supports of the sizes shown on City of Columbus Standard Detail Drawing L-6306 under all valves. Specify and provide valve restraints if necessary.

.1.1.2.5 Manufacturer's name and pressure rating shall be marked on valve body.

.1.1.3 A/E shall specify and design on the plans Thrust Restraints that comply with City of Columbus Section 801.

.1.1.3.1 Concrete for Thrust Restraints: Concrete shall be City of Columbus Class C.

.1.1.3.2 University Utilities requires that restrained joints (Megalug by EBAA Iron Inc., TR-Flex by US Pipe, Super Lock by Clow Corporation, or Flex-Ring by American Cast Iron Pipe Company) be installed at each fitting along with concrete thrust blocking.

1.1.4 Pipe shall have slip ring joints and fittings shall be Class 250 gray cast iron with mechanical joints.

1.1.5 Indicator Posts

.1.1.5.1 A/E shall coordinate indicator posts with the City of Columbus Fire Department, Fire Marshall, the University Landscape Architect, and City of Columbus Standards. Indicating posts shall be adjustable type and of sufficient length to allow that target windows be 30" above finished grade. Operating nut shall be National Standard Pentagon

measuring 1-1/2" from point to opposite flat, 1-1/4" square, with locking type operating wrench and shall turn counter-clockwise to open, Mueller No. A-20804 or as approved.

- Assembly to be tapped for, and provided with, supervisory switch.

#### 1.1.6 Fire Hydrant

.1.1.6.1 Fire Hydrant shall be Clow-Eddy model F-2641 or equivalent with break flange/compression type (AWWA C502-80) with 7/8 inch tapered to 1 inch operating nut (turning clockwise to open and counter-clockwise to close), rising center stem, safety coupling, compression type valve, 4-½-inch minimum valve opening, factory sealed drain opening, and a 4-inch pumper nozzle. Nozzle thread and finish shall comply with City of Columbus Fire Departments' standard. Hydrant shall be designed for 150 pounds working pressure and tested to 200 pounds hydrostatic pressure. Hydrants inlet connection shall be 6 inch mechanical joint type.

.1.1.6.2 Auxiliary shut off valves shall be Clow #F-5065 or equivalent with mechanical joints, cast iron body, bronze wedges, non-rising bronze stem and O-ring packing. Valve boxes shall be Clow #F-2450 cast iron three piece screw extension type with labeled lid as required by local code.

.1.1.6.3 Piping shall be Clow or equivalent mechanical joint ductile iron (AWWA C106) 250 pounds working pressure with cement-lining, Class 52 thickness bitumastic enamel coating, and rubber ring gasket.

.1.1.6.4 University fire hydrants and valve box lids are to be painted RED with the hydrant caps painted GRAY, similar to existing University hydrants.

.1.1.6.5 Specify that all of the fire hydrant backing shall be concrete. No wood backings allowed. A/E shall update and modify details on drawings to reflect the concrete blocking.

#### 1.1.7 Tapping Sleeves

.1.1.7.1 Specify that tapping sleeves shall comply with City of Columbus Section 803. OSU Utilities prefers JCM fabricated steel tapping sleeves or an approved equal.

.1.1.7.2 Specify that hot taps have to be submitted and approved by the A/E and OSU Utilities prior to hot tap being permitted.

.1.1.7.3 Specify prior to hot tapping that contractor shall expose the proposed hot tap location and confirm existing pipe material if not already known. Specify that hot taps are only permitted on existing or new ductile iron piping. Old existing cast iron water piping on campus will not be allowed to be hot tapped by OSU Utilities.



.1.1.7.4 The A/E shall design tapping sleeves for the use on the class of pipe the Contractor plans to tap.

.1.2 WATER SERVICE TAPS 2-INCH AND SMALLER

.1.2.1 Material: 2 inch and smaller, use Type K, soft temper copper tubing conforming in all respects to ASTM B 88 or Federal Specification WW-T-799 for all pipe from the water main connection to the control valve, unless specifically called for differently on the plans. Use fittings of high quality copper brass with approved compression type joints. Do not use fittings between the water main connection and the control valve, unless otherwise approved by OSU Utilities.

.1.3 VALVE BOXES

1.3.1 Specify cast iron per ASTM A 48 Class 30B screw type valve boxes with enlarged base and the necessary extensions based on depth of the water line.

1.3.2 Specify that each box lid shall have the word "WATER" cast neatly and legibly on it and held securely in place by a bronze or brass bolt.

.1.4 DISINFECTION CHEMICALS

.1.4.1 Chemicals: AWWA B300, Hypochlorite, AWWA B301, Liquid Chlorine

PART 3 - EXECUTION

.1 PREPARATION

.1.1 Remove scale and dirt on inside and outside before assembly.

.1.2 Prepare pipe connections to equipment with flanges or unions.

.1.3 Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs.

.2 BEDDING

.2.1 Hand trim excavation for accurate placement of pipe to elevations indicated.

.2.2 Excavate pipe trench per Item 801 of the Columbus Construction and Material Specifications.

.2.3 Place bedding material at trench bottom, level fill materials in one (1) continuous layer not exceeding six (6") inches compacted depth; compacted to 95% of the Standard Proctor maximum dry density.

.2.4 Form and place concrete for pipe thrust restraints at every change of pipe direction. Place concrete to permit full access to pipe and pipe accessories.

.2.5 Backfill around sides and to top of pipe with cover fill, tamp in place and compact to 95% of the Standard Proctor maximum dry density. Maintain optimum moisture content of bedding material to attain required compaction density.

.2.6 Specify installation of non-detectable utility marking tape. Marking tape shall be blue in color for water and associated lines.

.3 INSTALLATION

- .3.1 Water supply piping shall not be designed within campus tunnels.
  - .3.2 Design casing pipes for 6" or larger water supply piping crossings under tunnels or culverts.
  - .3.3 Pipe shall be routed in straight lines.
  - .3.4 Design water pipe and position drains at low points.
  - .3.5 Specify that the Contractor shall install ductile iron piping and fittings per AWWA C600.
  - .3.6 Design separation of water main from sewer piping 10' horizontally and 18" vertically. Water main should be placed above the sewer line preferably or a 20'-long protective casing should be specified.
  - .3.7 Specify that the Contractor shall install pipe to allow for expansion and contraction without stressing pipe or joints.
  - .3.8 A/E shall establish elevations of buried piping to ensure not less than 48-inches of cover. Field inspections by the A/E and Construction Manager (if applicable) shall confirm 48-inches of cover.
  - .3.9 Design and specify that the Contractor shall form and place concrete for thrust restraints at each elbow or change of direction of pipe main.
  - .3.10 Specify that the valve box shall be centered and plumb over valve.
  - .3.11 Specify that the valve box cover is flush with finished grade. OSU will not accept valve box covers that are not flush with finished grade.
  - .3.12 All valve boxes shall be extended to final grade or pavement.
  - .3.13 Valve boxes shall be furnished on all valves of water service piping.
  - .3.14 Specify and provide a detail on the drawings that a three- (3") inch galvanized steel pipe shall be installed in each valve box to prevent misalignment.
- .4 OPERATION
- .4.1 Specify that University personnel only will operate valves that affect the flow of water through water lines in service, or any valves installed against a University main. The University will not guarantee water-tight valve shutoffs. Coordinate all valve shutoffs with University personnel.
- .5 HYDROSTATIC TESTS
- .5.1 A hydrostatic test as required in Section 4 of the Standard AWWA Specification C600 shall be applied to the whole or in individual valved-off sections of the main and fire hydrant leads either before or after trench is backfilled. The pressure during the test shall be maintained at 150 PSI. The duration of each pressure test shall be at least one hour.

University Utilities shall witness and approve all hydrostatic pressure tests. Contractor shall provide materials and test certificate according to requirements of NFPA 13. University contact for hydrostatic tests is Utilities Manager of Support Services (phone: 614-292-6383). Specify that the project's contractor or Construction Manager shall contact OSU's Office of Emergency Management and Fire Prevention at 614-247-4911 to schedule a day and time with The State of Ohio Fire Marshall for inspection and witness of underground waterlines and hydrostatic tests. Specify that domestic cold

water lines shall not be buried until OSU Utilities and The State Fire Marshall have approved the installation.

.6 FLUSHING AND DISINFECTION

- .6.1 Perform operations in accordance with Item 801 of Columbus Construction and Material Specifications.
- .6.2 Verify that piping system has been cleaned, inspected, and pressure tested.
- .6.3 Perform scheduling and disinfecting activity with start-up, testing, adjusting and balancing, demonstration procedures, including coordination with related systems.
- .6.4 Provide and attach required equipment to perform the work of this Section.
- .6.5 Introduce treatment into piping system.
- .6.6 Maintain disinfectant in system for 24 hours.
- .6.7 Flush, circulate, and clean until required cleanliness is achieved; use domestic water.
- .6.8 Replace permanent system devices removed for disinfection.

.7 WATER SUPPLY OUTAGES

- .7.1 Specify that University personnel only will operate valves that affect the flow of water through water lines in service, or any valves installed against a University main. The University will not guarantee water tight valve shutoffs. Specify that the Contractor or Construction Manager must notify The Ohio State University, Facilities Operations and Development, 14 calendar days prior to any utility service outages. Representatives of The Ohio State University must be present at such outages. Failure to notify University Utilities in a timely manner will result in a denial of the requested utility outage. Utilities will work with the Contractor(s) to schedule the utility outage and installation; and University Utilities reserves the right to schedule the best time that fits within the requirement of the Campus at large and the local customers affected. For waterline work, University Utilities contact is Utilities Manager of Support Services, (phone: 614-292-6383).

**33 12 33. WATER UTILITY METERING**

.1 DOMESTIC WATER SUPPLY METERS

- .1.1 Temporary services shall be metered. Refer to Division One, 01 51 00.2 for metering requirements.
- .1.2 Water supply to buildings shall be metered for new buildings and major additions and renovations. (Part Four, FS-2.4)
- .1.3 Meters shall conform to the requirements and policies of the City of Columbus, Department of Public Utilities, and the AWWA as referenced. Meters shall read in cubic feet consistent with the City of Columbus requirements or as required by the authority having jurisdiction.
- .1.4 Remote registers shall be provided when the meter location prevents direct reading of the meter register from a standing position on grade or finished floor. Remote registers shall be installed at 4' to 5' above grade or finished floor. Remote registers shall be compatible with the installed meter, shall be

- from the same manufacturer, and shall have a straight reading odometer type display.
- .1.5 Meter shall provide one set of dry contacts that give a pulse output for every 10 cubic feet of usage recorded by the meter.
- .1.6 No battery powered registers, including remote registers, are permitted.
- .1.7 Easy access shall be provided to meters for maintenance, repairs, and meters shall be flanged and valved to permit convenient replacement of metering.
- .2 SEWER AUXILIARY METERS
  - .2.1 Complete metering of cooling tower make-up water, cooling tower system blow-down, cooling tower chemical treatment systems, irrigation systems, water cooled devices discharging directly to a storm sewer and any process that qualifies for deduct credit is required.
  - .2.2 Sewer Auxiliary Meters shall read in cubic feet and conform to requirements of and meet final inspection and approval by the City of Columbus Department of Public Utilities Division of Sewerage and Drainage or as required by the authority having jurisdiction.
  - .2.3 Yokes shall be used in the metering system whenever possible.
  - .2.4 Remote registers shall be provided when the meter location prevents direct reading of the meter register from a standing position on grade or finished floor. Remote registers shall be installed at 4' to 5' above grade or finished floor. Remote registers shall be compatible with the installed meter, shall be from the same manufacturer, and shall have a straight reading odometer type display.
  - .2.5 No battery powered registers, including remote registers, are permitted.
  - .2.6 Easy access shall be provided to meters for maintenance, repairs, and meters shall be flanged and valved to permit convenient replacement of metering.

**33 32 25 DRAINAGE SYSTEMS**

PART 1 – GENERAL

- .1 RELATED DOCUMENTS
  - .1.1 Drawings and general provisions of Contract, including General Conditions and Supplemental General Conditions, apply to this Section.
- .2 DESCRIPTION
  - .2.1 Gravity and pumped storm water and sanitary discharge from Utility tunnels and trenches including piping, equipment, and all necessary accessories as designated in this section.
- .3 REFERENCED CODES, STANDARDS AND APPLICABLE PUBLICATIONS
  - .3.1 General: The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
    - .3.1.1 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)

MSS SP-5	Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-6	Pipe Hangers and Supports - Selection and Application
MSS SP-110	Ball Valves-Threaded, Socket Welding, Solder Joint, Grooved and Flared Ends

.4 SUBMITTALS

.4.1 Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:

- .4.1.1 Manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting.
- .4.1.2 Piping schedule showing manufacturer, ASTM number, ASTM type, ASTM grade, pipe or tube weight, fitting type, and joint type for each piping system.
- .4.1.3 The piping and accessories submittal shall clearly describe what components are going to be used for each piping group.
- .4.1.4 Records and reports required for certain pipe groups as specified in individual piping group specifications.
- .4.1.5 Provide ISO 9001 and Independent Test Reports if applicable per Quality Assurance paragraph below.
- .4.1.6 "Fire Watch" safety procedures.

.4.2 Maintenance Data: In accordance with submit the following: Section 01 78 00 – CLOSEOUT SUBMITTALS

- .4.2.1 Maintenance data and parts lists for each type of mechanical fitting.

.4.3 Quality Control Submittals: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:

- .4.3.1 Manufacturer's Data: Copy of mill certificates, laboratory test and manufacturing reports relating to chemical and physical properties of pipe, fittings, and related materials.
- .4.3.2 Independent Testing Agency Qualifications: As specified in this Section.
- .4.3.3 ISO 9001 and Independent Test Reports: As specified in Quality Assurance below.

PART 2 – PRODUCTS

.1 PIPE, FITTINGS, AND JOINTS

.1.1 General: Items are referred to by type and shall conform to the latest editions of standards listed below:

.1.2 Pipe Materials:

Type	Designation
Copper water tube, Type K (heavy wall), Soft, ASTM B88	A

.1.3 Fitting Materials:

Type	Designation
Wrought copper and bronze drainage fittings, ANSI A16.29	I

.1.4 Joint Materials:

Type	Designation
Soldered: ASTM B32 tin-antimony 95-5	a

.1.5 Piping Assembly: Pipe, fittings, and joints shall be provided for each system based on the table below:

	Service Pipe	Fittings	Joints
.1.5.1 Pumped (forced), designated as "PSAN" On Contract Drawings			
.1.5.1.1 Underground	A	I	a
.1.5.1.2 Trenches and Manholes	A	I	a
.1.5.2 Gravity			
.1.5.2.1 Underground	A	I	a
.1.5.2.2 Manholes and Valve Vaults	A	I	a

.2 VALVES (SUMP PUMP DISCHARGES AND BEYOND)

.2.1 Shut-Off:

2.1.1 3 inches and Smaller: Single-piece, full port ball valve with replaceable internal parts. Valve shall have swing out design, bronze body, stainless steel, ball and stem (ASTM A276 Type 316), reinforced TFE Seats. Provide blow out proof stem and extended stem for insulation thickness. Body bolts and nuts shall be zinc dichromate plated steel. Valve shall be rated for 150 psig saturated steam service. Valve shall be soldered to suit piping system which it is installed.

.2.2 Check:

.2.21 3 inches and Smaller: Bronze body and bonnet, ASTM B61, or B62. 125 PSI, solder connections. Must be non-slam style. All check valves shall be lift or ball check style and installed in a vertical pipe run.

.2.3 Throttling:

.2.3.1 3 inches and Smaller: Globe style body with dial indicator handle for position setting shall be lockable in position. Valve will be used to add pressure drop for sump pump discharge to prevent pump curve run-out. Valve shall have bronze body and bonnet, ASTM B61 or B62, Class 125 with solder connections.

.3 MISCELLANEOUS

.3.1 Pipe Sleeves:

3.1.1 Sleeves in masonry and concrete walls, floors, roofs in accordance with ASTM A53, Schedule 40 or Standard Weight, hot-dip galvanized steel pipe sleeves.

3.1.2 Provide where piping passes entirely through walls, roofs, and floors. Secure sleeves in position and location during construction.

Provide sleeves of sufficient length to pass through entire thickness of walls, roofs, and floors. Sleeves shall be a complete system supplied by a single manufacturer similar to "Linkseal" by Thunderline Corp., or an approved equal mechanically adjustable segmented elastomeric seal rated for 300°F.

- .3.2 Pipe Hangers and Supports: Provide MSS SP-58 and MSS SP-69, Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to Steel W or S beams with Type 21, 28, 29, or clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel with drilled hole on gauge line and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor.
- .3.3 Flanges: Flanges shall be Class 150, Solder connection in accordance with ANSI B 16.24 and flat faced. Material shall conform to ASTM B 62.
- .3.4 Bolting Materials: Bolting shall consist of a bolt head which requires one nut on the opposite side on the threaded end in accordance with ANSI B 1.1, Class 2A. Material shall conform to ASTM A 193, Grade B7. Nuts shall be heat-treated, heavy, hexagonal nuts, semi-finished, and in accordance with ANSI B 18.2.2 and B1.1, Class 2B. Material shall conform to ASTM A 194, Grade 2H.
- .3.5 Gaskets: Gaskets shall be spirally wound, Type 304 Stainless Steel with non-asbestos filler material and carbon steel outer ring. Gasket shall be 1/16-inch thick and conform to the flange face on which they are used. Acceptable products from acceptable manufacturers include: Flexitallic Style CGI with Flexicarb Filler and 316L winding, manufactured by Flexitallic Inc., or approved equal.

.4 DRAINAGE SUMP PUMPS

- .4.1 Refer to Section 33 32 30 – DRAINAGE PUMPS

PART 3 – EXECUTION

.1 INSTALLATION

1.1 General:

- .1.1.1 Install piping from tunnel or trench drain to manhole sump to (but not including) piping in trench (stainless steel) as shown on P Series and Civil drawings. Pump discharge pipe shall penetrate the utility structure with a watertight pipe sleeve and seal and extend to approximately 3'-0" below grade and then pitch down at a minimum slope of 2% to the sewer system.
- .1.1.2 Pipe shall be round and straight. Cutting shall be done with proper tools.
- .1.1.3 All pipe runs shall be laid out to avoid interference with other work.
- .1.1.4 Installation of piping system, materials and workmanship shall be in accordance with the applicable Plumbing Code.

1.2 Pipe Supports

- 1.2.1 Maximum spacing between supports:

- 1.2.2 Vertical Piping: Support piping at 5 foot intervals.
- 1.2.3 Horizontal Piping: Support piping at 10 foot intervals and support piping at each change of direction.

.2 TESTS

- .2.1 General: Test system either in its entirety or in sections.
- .2.2 Sump Pump Piping:
  - 2.2.1 Water Pressure Test: If entire system is tested, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening of section under test, fill each section with water and test with at least 50 PSIG of water. Keep water in system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
  - 2.2.2 Correct defects and repeat tests until work is in compliance with contract requirements. Furnish water, electricity, instruments, connecting devices, and personnel for performing tests.

**33 32 30 DRAINAGE PUMPS**

PART 1 – GENERAL

.1 RELATED DOCUMENTS

- .1.1 Drawings and general provisions of the Contract, including General Conditions and Supplemental General Conditions, and other Division 01 Specification Sections, apply to this Section.
- .1.2 Refer to Division 48 Section “Low Voltage Electrical Power Conductors and Cables” for wiring requirements.

.2 SUMMARY

- .2.1 This Section specifies submersible drainage pumps including sump pumps.

.3 SUBMITTALS

- .3.1 General: Submit the following:
  - .3.1.1 Product data including certified performance curves, weights (shipping), furnished specialties, and accessories, plus installation and start-up instructions
  - .3.1.2 Shop drawings showing layout of sump pit and connections for submersible drainage pump
  - .3.1.3 Auxiliary high level float switch
  - .3.1.4 Wiring diagrams detailing wiring for power, signal, and control systems; differentiating between manufacturer-installed wiring and field-installed wiring
  - .3.1.5 Maintenance data for pumps and switches, for inclusion in Operating and Maintenance Manuals

.4 QUALITY ASSURANCE



- .4.1 Hydraulic Institute Compliance: Design, manufacture, and install submersible drainage pump in accordance with “Hydraulic Institute Standards.”
- .4.2 National Electrical Code Compliance: Components shall comply with NFPA 70 “National Electrical Code.”
- .4.3 UL Compliance: Submersible drainage pump shall be listed and labeled by UL and comply UL Standard 778 “Motor Operated Water Pumps.”
- .4.4 NEMA Compliance: Electric motor and components shall be listed and labeled NEMA.
- .4.5 SSPMA Compliance: Test and rate submersible drainage pump in accordance with the Sump and Sewage Pump Manufacturers Association (SSPMA) Standards.
- .4.6 Design Criteria:
  - .4.6.1 The Drawings indicate size, profile, connections, and dimensional requirements of sump pumps and are based on the specific manufacturer type and model indicated. Pumps having equal performance characteristics by other manufacturers may be considered, provided that deviations in dimensions and profiles do not change the design concept or intended performance as judged by the A/E. The burden of proof for equality of the pumps is on the Contractor.
  - .4.6.2 The design of drainage pumps and sump level alarm systems in utility tunnels will consider the risk of flooding due to pump failure or excessive hydraulic loads caused by flooding or pipeline failure.
- .5 DELIVERY, STORAGE, AND HANDLING
  - .5.1 Store pump in a dry location.
  - .5.2 Retain shipping protective covers and protective coatings during storage.
  - .5.3 Protect pump internals against damage from sand, grit, and other foreign matter.
  - .5.4 Comply with manufacturer’s rigging instructions for handling

## PART 2 – PRODUCTS

- .1 MANUFACTURERS
  - .1.1 Products: Subject to compliance with requirements, provide one of the following:
    - .1.1.1 High Temperature Submersible Sump Pumps:
      - Weil
      - Federal
      - Crane Barnes
      - Goulds
      - Zoeller
- .2 SUBMERSIBLE DRAINAGE PUMPS – DUPLEX SYSTEM
  - .2.1 General Description: Pumps shall be vertical, centrifugal, end suction, single stage, complete with integral inlet strainer and float switch controls. The pump shall be rated to handle liquids in continuous duty up to 200°F. The pump shall have 1/2-inch solids handling capability.

- .2.2 Casing: Stainless steel with integral stainless steel inlet strainer and stainless steel or Ryton legs to elevate the pump to permit flow into the impeller. Discharge female threaded connection shall be arranged for vertical discharge and suitable for plain-end pipe connection. Provide stainless steel lifting ring, screws, and bolts.
- .2.3 Impeller: Statically and dynamically balanced, open or semi-open, overhung, single suction, vortex style, fabricated from Nylon or stainless steel, keyed to shaft and secured by a locking capscrew. Volute to be stainless steel.
- .2.4 Pump and Motor Shaft: Cold rolled steel. Upper and lower bearings shall be INPRO bearing isolators. More information can be found at:  
<http://www.inpro-seal.com/>
- .2.5 Seals: Mechanical seals. Stainless steel spring, Viton parts, carbon and Ni-Resist faces.
- .2.6 Submersible Motor: 460V, 3-phase, 60 hertz, as scheduled, oil filled for rapid heat dissipation, with 15-foot, 3-conductor SOOW Type cord with bare lead ends. Motor shall be high temperature, rated for submerged in 212°F water.
- .2.7 Basin: Concrete construction under Division 3, Section 03 30 00.
- .2.8 Duplex Sump Pump Control Panel: A dedicated control panel in a wall mountable NEMA 4X stainless steel enclosure with a lockable disconnect is required. The Duplex Pump control panel shall utilize a four float system. Floats to initiate pump stop, lead pump start, lag pump start, and high water alarm. "Lead" and "lag" pumps will alternate. Duplex control panel shall include two motor starters with separate overload relays, two red pump run lights one for each pump, two pump motor overload amber indication lights one for each pump, two resettable pump run time hour meters one for each pump, two hand-off-auto switches one for each pump, one dedicated and separately fused control circuit transformer, one high water alarm with test mode and isolated output contact, one high water alarm amber indication light, one lag pump alarm with test mode and isolated output contact, and one amber lag pump alarm amber indication light. Duplex Pump panel high water and lag pump alarm contacts to be utilized as determined by the design and flood risk assessment. Duplex Pump panel high and lag pump alarm annunciation can be through Building Automation System, campus security system or Utility central control system.
- .2.9 Sump Disconnect Panel and Starters: Specified in Division 48. Disconnect panels shall be located in sump manhole. Starters shall be installed in remote building per Electrical Drawings.
- .2.10 Float Switches:
  - .2.10.1 Provide 4 floats on one stand mounted to bottom of sump manhole. Floats shall have adjustable settings. Floats shall be rated for 90°C (194°F) service. Anchor Scientific manufactures the "Roto float-SST, Type P" float switch that has the highest temperature rating believed to be commercially available. High level float switch shall be normally closed.
  - .2.10.2 Sump float switches shall be mounted from top to bottom in the following order:

.2.10.2.1 Lag Pump On

.2.10.2.2 High Level Alarm

.2.10.2.3 Lead Pump On

.2.10.2.4 Lag and Lead Pump Off

.2.10.3 Pump sequence of operation shall be as follows:

.2.10.3.1 Sump empty: Pumps off.

.2.10.3.2 Sump level rises to lead pump float switch: Start lead pump.

.2.10.3.3 Sump level rises to a high level alarm float switch: Activate remote alarm.

.2.10.3.4 Sump level rises to lag pump float switch: Start lag pump.

.2.10.3.5 Shut off pumps when level falls below low level float switch.

.2.10.3.6 The design intent of the alarm is such that an intermittent high level alarm will indicate a lead pump failure and a continuous high level alarm will indicate both lead and lag pump failures.

.2.11 Install a non-slam lift or ball check valve and gate valve on the discharge side of pump.

### PART 3 – EXECUTION

#### .1 EXAMINATION

.1.1 Examine areas, concrete sump and conditions for compliance with requirements for installation and other conditions affecting performance of submersible drainage pump. Do not proceed with installation until unsatisfactory conditions have been corrected.

.1.2 Examine rough-in for drainage piping system to verify actual locations of piping connections prior to installation.

#### .2 INSTALLATION

.2.1 General: Comply with the manufacturer's written installation and alignment instructions.

.2.2 Install pump in location and arrange to provide access for periodic maintenance, including removal of entire pump assembly from pit; allow for maintenance, repair and replacement of motors, impellers, couplings, and accessories.

.2.3 Support pump and piping separately so that the weight of the piping system does not rest on the pump.

.2.4 Basin/sump pit: Install submersible drainage pump in indicated location and connect to drainage discharge line. Refer to Division 3 for concrete work.

#### .3 CONNECTIONS

.3.1 General: Install valves that are same size as the piping connecting the pump.

.3.2 Install discharge pipe size equal to or greater than the diameter of the pump nozzle.

- .3.3 Install a non-slam lift or ball check valve and gate valve on the discharge side of pump.
- .3.4 Electrical wiring and connections are specified in Electrical Sections.

.4 COMMISSIONING

- .4.1 Final checks Before Start-Up: Perform the following preventative maintenance operations and checks before start-up:
  - .4.1.1 Lubricate oil-lubricated bearings.
  - .4.1.2 Remove grease-lubricated bearing covers and flush the bearings with kerosene and thoroughly clean. Fill with new lubricant in accordance with the manufacturer's recommendations.
  - .4.1.3 Check that pump is free to rotate by hand. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.
  - .4.1.4 Test the high level switch. Prove alarm operation.
  - .4.1.5 Test all float switches and their elevations.

**33 40 00. STORM DRAINAGE UTILITIES**

- .1 PREPARATION OF DOCUMENTS: Before preparing final documents, consult the University Architect. On some projects, it might be desirable to make this work a part of the Plumbing Contract.
- .2 MATERIALS: The City of Columbus Specifications and Standard Construction Drawings shall apply for work within Franklin County. Work outside Franklin County shall use local codes or ODOT, whatever is stricter.
  - .2.1 PIPING
    - FOR PIPE 12" and larger:
      - Reinforced Concrete pipe
      - Corrugated Polyethylene Pipe and fittings – smooth interior – type S
      - Ribbed Poly Vinyl Chloride (PVC) – smooth interior – Uni-bell
    - FOR PIPING less than 12":
      - Service weight cast iron
      - Poly Vinyl Chloride (PVC) – smooth interior – Type PSM
      - Ribbed Poly Vinyl Chloride (PVC) – smooth interior – Uni-bell
      - Corrugated Polyethylene Pipe and fittings – smooth interior – type S
  - .2.2 CATCH BASINS, CURB INLETS, MANHOLES
    - .2.2.1 BASIN LID AND FRAME: Cast iron construction, heavy duty, removable lid.
    - .2.2.2 SHAFT AND TOP SECTION: Reinforced precast concrete, lipped male/female joints; nominal dimensions as shown on plans. Cast-in-place, brick or block side walls may be used in place of precast construction. Brick or concrete block side walls shall be 8 inches nominal thickness. When brick or concrete block is used, the outside walls of the manhole shall be plastered with a 1/2-inch coat of lime cement mortar.

- .2.2.3 BASE PAD: Cast-in-place concrete of type specified in Section 03 30 00; leveled top surface to receive concrete shaft sections, sleeved to receive storm sewer pipe sections. Precast base sections may be used in lieu of cast-in-place base.
- .2.3 UNDER DRAINS
  - .2.3.1 FILTER AGGREGATE: ODOT #8/Type H.
  - .2.3.2 TUBING: Polyethylene tubing, ASTM F-405
- .2.4 CLEANOUTS
  - .2.4.1 CLEANOUTS SHALL BE adjustable, vandal-proof with heavy duty cast iron top for exterior use.
- .2.5 TRENCH DRAINS
  - .2.5.1 LID AND FRAME: Cast iron construction, heavy duty, minimum 4" wide inside conduit size
  - .2.5.2 SURFACE DRAINAGE: Must have slope no less than 1 percent to insure positive drainage. Drain away from sidewalks and driveways.
  - .2.5.3 YARD/AREA DRAINS: Are not generally permissible. If one is needed, approval is needed from University Engineer.
  - .2.5.4 BENDS IN PIPING AND AT MANHOLES: All piping shall be run straight, structure-to-structure. If a bend is necessary, a cleanout shall be provided. Transitions at manholes shall not be 90 degrees or less.
- .2.6 DRAIN OPENING PROTECTION: Install removable bars or grills at open ends of culverts, drains and pipes 10-inch diameter and larger to prevent access by children or animals.
- .2.7 MANHOLES AND CATCH BASINS:
  - .2.7.1 Refer to City of Columbus standard drawings for manhole and catch basin standard materials and installation requirements within Franklin County and the State of Ohio Department of Transportation standard drawings for work outside Franklin County.
  - .2.7.2 Refer to City of Columbus and the Ohio Department of Transportation construction and materials specifications for minimum requirements.
- .2.8 STORM WATER MANAGEMENT FACILITIES:
  - .2.8.1 Proprietary materials used in storm water best management practices (BMPs) need approved by University Engineer.

**33 51 13 UNDERGROUND NATURAL GAS LINES**

PART 1 - GENERAL

.1 REFERENCES

Current versions of the following:

- .1.1 NFPA 54 - National Fuel Gas Code
- .1.2 ANSI B31.8 - Gas Transmission and Distribution Piping Systems

- .1.3 American Gas Association, AGA
  - .1.4 Code of Federal Regulation (CFR) Title 49 Part 192 – Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
  - .1.5 ASTM D2513 – Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings
  - .1.6 ASTM F2620 – Standard Practice for Heat Fusion Joining of PE Pipe and Fittings
  - .1.7 ASTM D3350 – Standard Specification for PE Plastics Pipe and Fittings Materials
  - .1.8 All other applicable Federal, State of Ohio, ANSI, ASTM, ASME standards
  - .1.9 Ohio Administrative Code 4901:1 Utilities
  - .1.10 Columbia Gas of Ohio – Materials for Customer Service Lines
  - .1.11 Columbia Gas of Ohio – Standards for Customer Service Lines, Meters, and Service Regulators (Plumber’s Guide)
- .2 QUALIFICATIONS
- .2.1 The Ohio State University Utilities Division requires all natural gas line installers provide written and performance verification of Department of Transportation (DOT) Operator Qualifications for all individuals performing covered tasks on Columbus Campus natural gas pipelines. Being “qualified” means that a Third Party Qualifier has evaluated and verified the contractor’s ability to perform the various covered tasks. Natural gas line work will not be allowed to commence until all individuals qualifications are submitted for review and approval.
  - .2.2 Experience: Specify that the Contractor shall provide examples and demonstrate previous relevant experience for all covered tasks and gas pipeline construction work included in the contract documents.
- .3 SUBMITTALS
- .3.1 Contractor shall submit a list of materials to be furnished, the names of the suppliers, and the appropriate shop drawings for all PE pipe, fittings, and valves as required in the Project Specifications. Pipe dimension ratio (DR) computation, minimum bend radius, and other physical properties shall be included with the submittal.
  - .3.2 A/E shall specify that the Contractor shall submit shop drawings showing installation method and the proposed method and specialized equipment to be used, including but not limited to manufacturer’s recommended fusing procedures for the products.
  - .3.3 A/E shall specify that Contractors shall submit DOT Operator qualifications and resumes for all personnel performing installation, excavation, backfilling, fusing, welding, and supervising of PE pipe for each covered task. This includes, but is not limited to written, verifiable proof that the Contractor is certified by the fusion systems manufacturer(s) as a fully-trained user. Contractor shall comply with qualifications as stated above and submit required qualification data.
  - .3.4 Specify that the Contractor shall submit steel pipe welder information.
    - .3.4.1 Welder Qualification Data: Copies of certification; include names, home addresses and identification numbers of welders.

- .3.4.2 Welding Procedures: Shall include QW-482 "Suggested Format for Welding Procedure Specification (WPS)" and QW-483 "Suggested Format for Procedure Qualification Record (PQR)" for different weld types.
- .3.4.3 Welders' Certificates: Shall include QW-484 "Suggested Format for Manufacturer's Record of Welder or Welding Operator Qualification Tests (WPQ)" for all welders for all weld types.
- .3.5 Incomplete, insufficient, or out of date DOT Operator qualifications are not acceptable.
- .3.6 OSU Utilities does not provide qualification services for natural gas line installers. The contractor shall obtain all DOT Operator qualifications necessary to perform the work.
- .3.7 A/E shall specify that the Contractor shall submit fusion map showing placement of all proposed joints. Joints shall be numbered individually.
- .3.8 A/E shall provide PE-to-Steel transition fitting details on the Contract Drawings, and specify at minimum, that the Contractor shall include the fabricator's name, qualification, and quality compliance verification. It shall also include detailed dimension of the fitting, material used, fabrication process, test method, and any special field handling requirements.
- .4 DESIGN AND INSPECTIONS
  - .4.1 Specify that each length of pipe and each other component must be visually inspected at the site of installation to ensure that it has not sustained any visually determinable damage that could impair its serviceability.
  - .4.2 All natural gas pipeline work shall be inspected by the University and the A/E to ensure that it is constructed in accordance with Code. The University has the authority to halt construction if specifications and standard construction practices are not being followed. Whenever any portion of these specifications is violated, the University may order further construction to cease until all deficiencies are corrected.
  - .4.3 The Public Utilities Commission of Ohio (PUCO), has identified OSU Utilities as the Operator of the Columbus Campus Master Meter Gas Pipeline Systems. OSU Utilities is also the Authority Having Jurisdiction (AHJ) for Columbus Campus natural gas pipelines. OSU Utilities will comply with Federal and State regulations to provide a safe, reliable natural gas system. As the Operator of the system on Columbus campus, OSU Utilities is accountable for all aspects of the installation, maintenance, and operation of the system. Natural gas system contractors must adhere to all Federal and State laws and regulations, and OSU Utilities policies and procedures, or be disqualified from construction or servicing work on gas pipeline systems.
- .5 WARRANTY AND ACCEPTANCE
  - .5.1 Specify that all work shall be warranted free from defects in workmanship and materials for a period of one year from the date of completion of all construction.

PART 2 - PRODUCTS

- .1 MEDIUM DENSITY POLYETHYLENE PIPE (YELLOW) AND FITTINGS
  - .1.1 Specify medium density polyethylene pipe (yellow) for natural gas piping on OSU's Columbus Campus whose operating pressure will be below 25 psig.
  - .1.2 Provide polyethylene pressure pipe and fittings manufactured from PE2406/PE2706 medium density polyethylene meeting ASTM D2513 standards. Resin shall meet the requirements of ASTM D 3350.
  - .1.3 Pipe shall be legibly marked, at intervals of no more than 5 feet. 40' long sections shall be used for the pipe that is installed by horizontal directional drill method.
  - .1.4 Where medium density PE pipe is joined to medium density PE pipe, it shall be by thermal butt fusion. Fusion shall be accomplished in accordance with the pipe manufacturer and fusion equipment supplier specifications.
  - .1.5 Fittings and Custom Fabrications: Shall comply with ASTM D2513 or ASTM D2683. Fittings and custom fabrications shall be provided of the same resin as the adjacent pipe. Butt fusion outlets shall be made to the same outside diameter, wall thickness, and tolerances as the mating pipe.
  
- .2 HIGH DENSITY POLYETHYLENE PIPE (BLACK) AND FITTINGS
  - .2.1 Specify high density polyethylene pipe (black) for natural gas piping on OSU's Columbus Campus whose operating pressure will be between 50 psig - 100 psig.
  - .2.2 Provide polyethylene pressure pipe and fittings manufactured from PE4710 high density polyethylene meeting ASTM D2513 standards. Resin shall meet the requirements of ASTM D 3350.
  - .2.3 Pipe shall be legibly marked, at intervals of no more than 5 feet. 40' long sections shall be used for the pipe that is installed by horizontal directional drill method.
  - .2.4 Where High Density Polyethylene (HDPE) pipe is joined to HDPE pipe, it shall be by thermal butt fusion. Fusion shall be accomplished in accordance with the pipe manufacturer and fusion equipment supplier specifications.
  - .2.5 Fittings and Custom Fabrications: Fittings and custom fabrications shall be provided of the same resin as the adjacent pipe. Butt fusion outlets shall be made to the same outside diameter, wall thickness, and tolerances as the mating pipe.
  - .2.6 Fabricated Fittings: Fabricated fittings shall be made by heat fusion joining specially machined shapes cut from pipe in accordance with ASTM F2206. Directional fittings 12" and larger, such as elbows, tees, etc., shall have a plain-end inlet for butt fusion and plain-end directional outlets.
  
- .3 STEEL PIPE AND FITTINGS
  - .3.1 Specify all pipes through 12-inches shall be seamless carbon steel conforming to ASTM A53 Grade B Type S or ASTM A 106 Grade B Type S. Pipe shall have a wall thickness of schedule 40. Specify that shop or factory applied epoxy coating shall be provided.



- .3.2 Specify that epoxy coating shall be a 100% solid, thermosetting, fusion-bonded, dry powder epoxy resin. Color shall be per Part 3-Execution; Section .6-PAINTING.
- .3.3 Specify that shop or field applied epoxy coating for repairs and patching shall be a two-component, 80% solid, and liquid epoxy resin. Color shall be per Part 3-Execution; Section .6-PAINTING.
- .3.4 All threaded pipe nipples shall be Schedule "XSTG" conforming to ASTM A 106, Grade B.
- .3.5 Joints 2-inches and smaller shall be socket welded.
- .3.6 Joints larger than 2-inches shall be butt welded.
- .3.7 All sizes shall be flanged where required to connect to flanged valves, fittings, or equipment.
- .3.8 Flanges shall be Class 150 welding neck type in accordance with ANSI B16.5 and flat faced, except they shall be Class 300 and raised face to match existing. Material shall conform to ASTM A 105. Welding neck flanges shall be bored to match the same ID as the attached pipe.
- .3.9 Fittings 2 inches and smaller shall be 3000 pound socket-weld in accordance with ANSI B16.11. Material shall conform to ASTM A 105.
- .3.10 Fittings 2-1/2 inches and larger shall be seamless forged steel, butt-welding type in accordance with ANSI B16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 234, Grade WPB.
- .3.11 Bolting shall consist of a bolt head which requires on nut on the opposite side on the threaded end in accordance with ANSI B1.1, Class 2A. Material shall conform to ASTM A 354 Grade BD. Nuts shall be heat-treated, heavy, hexagonal nuts, semi-finished and in accordance with ANSI B18.2.2 and B1.1, Class 2B. Material shall conform to ASTM A 194, Grade 2H. Bolt isolators shall be provided where necessary.
- .3.12 Unions 2 inches and smaller shall be 3000 pound forged steel socket weld with steel to steel seats. Material shall conform to ASTM A 105.
- .3.13 Unions 2-1/2 inches and larger shall be made with flanges.
  
- .4 Transition Fittings: Specify manufactured pipe fitting with one PE pipe end for thermal butt fusion connection to PE pipe and with one ASTM A53, Schedule 40 steel pipe end for welded connection to the steel pipe.
- .5 Service-Line Risers: Specify manufactured PE pipe fitting with PE pipe inlet for thermal butt-fusion connection to underground PE pipe; PE pipe riser section with protective-coated, anode less, steel casing and threaded connection to above ground steel piping.
- .6 VALVES
  - .6.1 Each valve shall meet the minimum requirements of API 6D. A valve may not be specified under operating conditions that exceed the applicable pressure-temperature ratings contained in those requirements.
  - .6.2 Each valve shall comply with the following:
    - .6.2.1 The valve must have a maximum service pressure rating for temperatures that equal or exceed the maximum service temperature.

- .6.2.2 The valve shell must be tested in the fully open position with no leakage.
- .6.2.3 The valve seat shall be pressure tested.
- .6.2.4 Each valve shall be able to meet the anticipated operating conditions.
- .6.3 Valve Boxes:
  - .6.3.1 Specify cast-iron lid and top rim, plastic slide adjustment shaft, cover stamped with "GAS" lettering, bottom section with base to fit over valve and barrel a minimum of 5-inches in diameter, and adjustable extensions of length required for bury depth.
  - .6.3.2 Suggested Manufacturer is Bingham and Taylor, series 500 Plastic Valve Boxes.
- .7 PRESSURE REGULATORS
  - .7.1 Specify self-operated diaphragm-type natural gas regulators. Consult with OSU Utilities for the natural gas distribution system pressure provided in the area of service.
  - .7.2 Specify that each pressure regulator relief vent shall be:
    - .7.2.1 Rain and insect free
    - .7.2.2 Located at a place where gas from the vent can escape freely to the outside atmosphere to a safe location away from openings into the building.
    - .7.2.3 Elevated to prevent submergence in areas where floods may occur.
    - .7.2.4 Protected from damage.
    - .7.2.5 Short as practical.
    - .7.2.6 If tubing is used for the vent line, the tubing shall be metallic and one size larger than the vent opening.
- .8 HOT TAPPING AND PLUGGING
  - .8.1. When necessary, specify hot tapping and plugging existing natural gas pipeline(s) on The Ohio State University property while continuously maintaining natural gas service to campus facilities.
  - .8.2. Specify that the hot tap fittings shall be full encirclement, low profile spherical 3-way tee. All plugs and fittings shall be specified and rated for the operating and test pressures.
  - .8.3. Specify that the contractor shall provide means to pull back the cut coupon out of the pipe and turn the coupon over to the University.
- .9 GAS PIPELINE MARKERS
  - .9.1 When applicable under Federal Safety Standards 192.707, specify that the contractor shall provide and install post markers where called for on the contract drawings. Posts shall be 2-inch diameter white PVC pipe with top cap. Post shall be 5-feet in length, buried in the ground 2-feet and extending above grade by 3-feet. Label on post shall be UV stable, yellow in color with black lettering with letters that are 1-inch high by ¼" stroke that reads as follows:

“WARNING GAS PIPELINE  
THE OHIO STATE UNIVERSITY (OSU)  
CONTACT SERVICE2FACILITIES AT 614-292-6158”

PART 3 - EXECUTION

.1 INSTALLATION OF PIPE AND FITTINGS

- .1.1 Specify that installation of all polyethylene and steel pressure pipes shall be as shown on plans and per Manufacturer’s requirements. Piping shall not be run under buildings or basement floors.
- .1.2 High static electric charges can develop on plastic piping products; observe all safety procedures for controlling and discharging static electricity and all requirements for personal protection.
- .1.3 Establish elevations of buried main piping to ensure not less than thirty-six (36") inches of cover.
- .1.4 Each main pipe line shall be installed with at least 12 inches of clearance from any other underground structure not associated with the main line. If this clearance cannot be attained, the main line shall be protected from damage.
- .1.5 Installation of new main gas pipes in the University’s tunnel system is prohibited.
- .1.6 PE mains shall be installed with sufficient clearance or must be insulated from any source of heat so as to prevent the heat from impairing the serviceability of the main pipe.
- .1.7 Each buried service line to the facility must be installed with at least 12 inches of cover on the building’s property and at least 18 inches of cover in streets and roads.
- .1.8 Where an underground structure (e.g. Duct bank, Tunnel) prevents the installation of a main line or a service line with the minimum cover, the main line or service line in question may be installed with less cover if it is provided with additional protection to withstand anticipated external loads.
- .1.9 Wrap valve and valve box with polyethylene tape and heat shrink.
- .1.10 Each valve installed in plastic pipe must be designed so as to protect the plastic material against excessive torsional or shearing loads when the valve or shutoff is operated, and from any other secondary stresses that might be exerted through the valve or its enclosure.
- .1.11 Center and plumb valve box over valve. Set box cover flush with finished ground surface. Prevent shock or stress from being transmitted through valve box to valve.
- .1.12 Each tap made on a pipeline under pressure must be performed by personnel trained and qualified to make hot taps, with demonstrable prior experience.
- .1.13 At each branch off of the main pipeline, the A/E shall design for three-valve clusters at the branch location.
- .1.14 Provide isolation fittings, cathodic protection, and test stations for each underground steel piping system.
- .1.15 Underground buried steel piping shall be protected with anodes and shall be provided with test stations as follows:

Schedule 40 Pipe Magnesium Anode

Pipe Size (inches)	Anode Size (pounds)	Anode Spacing (feet)
2 or smaller	5	100
2-1/2	5	70
3	17	180
4	17	140
6	17	95
8	17	75
10	32	110
12	32	95

- .1.16 Conform to Columbia Gas of Ohio, Inc. standards and specifications for magnesium anodes, anode size, and attachment method. Loop lead wire around the pipe to reduce possible stress on connection.
- .1.17 Test Stations for Anode Protected Gas Pipe: Each isolated gas pipe system must have at least 2 test stations. Maximum spacing between test stations is 300 feet. Each test station shall be located in a plastic curb box identical or equal to those used by Columbia Gas of Ohio, Inc. Connections to the pipe shall be the same as required for anodes and shall have two single strand, single conductor, No. 12 copper lead wires extending from the pipe connection to the terminal block at grade in the curb box.
- .1.18 Specify that the Contractor shall provide and install insulating flange at the point of service entrance, to electrically isolate interior and exterior piping.
- .1.19 Steel gas piping shall not be used as a grounding electrode.
- .1.20 Gas piping shall enter the building above grade. Wall shall be sleeved and caulked at entrance.
- .1.21 Gas distribution piping standards in this Division 33 shall be applied on all gas pipelines up to the building pressure regulator.
- .1.22 Natural gas meter and regulator settings (with or without regulator vents) shall be located a minimum 10'-0" radius away from electrical equipment; 3'-0" away from any window or opening; 2'-0" away from any communications box or water spigot; and 12" away from the corner of a building. The bottom of the gas meter shall have a 6" minimum clearance above finish grade and the bottom of the gas line shut-off shall have an 8" minimum clearance from finish grade.
- .1.23 Specify non-detectable 6-inch wide polyethylene marking tape that is yellow in color with black lettering "Buried Gas Line".
- .1.24 Squeeze-off is a technique used to control the flow of gas or liquid in PE pipe by compressing the pipe between two parallel bars until the surfaces make contact. Specify that approval must be granted by the A/E and the University prior to a contractor "squeezing off" new or existing plastic pipeline(s). If approved, Contractors utilizing squeeze-offs must have the correct tools, follow the pipe manufacturer's requirements, be within ASTM standards and address indicated safety concerns. Note that there are also static electricity concerns for gas squeeze-offs. Proper safety and grounding procedures shall be in place during squeeze-off operations.

.2 FUSION JOINING

- .2.1 Butt Fusion Joining – Contractor shall make joints between plain end pipes and fittings by butt fusion using only procedures that are recommended by the pipe and fitting Manufacturer and ASTM F2620.
  - .2.2 Ensure that persons making butt fusion joints are certified according to the standards and have proven experience to make fusion welds following Manufacturer's recommended procedures.
  - .2.3 External and internal beads resulting from butt fusion joining shall not be removed.
  - .2.4 Use caution to protect the exposed butt ends of pipes from exposure to oils, greases, or hydrocarbons. Any pipe exposed to hydrocarbons of any type shall be cut-out and removed prior to butt fusion.
- .3 FOUNDATION AND BEDDING
- .3.1 Lay pipe on grade and on a stable foundation. Remove unstable or mucky trench bottom soils, and install a 6-inch bedding of sand per City of Columbus Item 703.05 to pipe bottom grade. Deposit sand to a depth of 3 inches above the piping. Compaction rates should be as specified in ASTM D2321. Remove excess groundwater from the trench before laying the foundation or bedding and the pipe. Pipe shall be laid when the conditions of trench are dry. A trench cut in rock or stony soil shall be excavated to 6 inches below pipe bottom grade, and brought back to grade with bedding material noted above. Remove all ledge rock, boulders, and stones larger than 3 inches in any dimension from excavated trench prior to placing sand bedding and pipe.
- .4 PIPE HANDLING
- .4.1 At all times through delivery, storage, on-site staging and installation, the Contractor shall protect and ensure that the HDPE pipe is not exposed to liquid hydrocarbons. If any portions of the pipe are exposed to hydrocarbons, that section of pipe shall be cut-out and removed from use.
  - .4.2 The Contractor shall exercise care in pipe handling. Gouges exceeding 10% of pipe wall thickness shall be cause for rejection of the pipe.
- .5 TRACER WIRE
- .5.1 Tracer wire shall be placed with all plastic pipe and shall be insulated, #12 AWG Reinforced Tracer Wire. Direct burial #12 AWG solid, 21% conductivity annealed copper-clad high carbon steel high strength tracer wire, 380# average tensile break load, 30 mil high molecular weight, high density yellow polyethylene jacket complying with ASTM D-1248, 30-volt rating. The tracer wire shall be connected to valves. The buried sections of tracer wire shall be continuous.
  - .5.2 All splices or connections shall be made at accessible locations inside vaults. All spliced or repaired wire connections in the tracer wire system shall be made using a Wing Nut Wire Connector (for two to four number ten wires), and made waterproof using an approved buried service wire closure.
  - .5.3 The tracer wire shall be tested upon completion of the installation to ensure conductivity for locating. If any areas appear to be disconnected or

conductivity appears incomplete, the tracer wire shall be excavated, inspected and replaced.

.5.3.1 Tracer wire may not be wrapped around the pipe and contact with the pipe must be minimized but is not prohibited.

.6 PAINTING

.6.1 Specify that the Contractor shall paint exterior exposed metal service piping, service valves, service regulators, service meters and meter bars, and piping specialties except units with factory-applied paint or protective coating. Yellow epoxy paint shall normally be used. Exterior and exposed natural gas piping on or near campus buildings with high and sensitive visibility shall have the paint color approved by the University Landscape Architect and OSU Utilities. See also Part 2-Products; Section .3 STEEL PIPE AND FITTINGS.

.6.2 Specify that the Contractor shall paint buried metal valve boxes and their metal covers with rust inhibitive primer and one (1) coat of yellow epoxy paint.

.6.3 Damage and Touchup: Specify that the contractor shall repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

.7 TESTING, PURGING AND INSPECTION

.7.1 Pressure Testing:

.7.1.1 For gas lines operating less than 25 psig, specify that the pressure test shall be at 90 psig and hold for 24 hours to be considered an acceptable pressure test.

.7.1.2 For gas lines operating between 50 psig - 100 psig, specify pressure test shall be at 90 psig or 150 percent of the maximum operating pressure, whichever is greater, and hold for a minimum of 6 hours to be considered an acceptable pressure test.

.7.2 Nitrogen shall be used to pressure test the pipe.

.7.3 Pressure tests shall be by a recording line chart over 24 consecutive hours. Specify that the original recording line chart shall be turned over to OSU Utilities for record keeping.

.7.4 Specify that temporary natural gas piping used for buildings under construction shall be metered, undergo and pass a pressure test, and be witnessed by OSU Utilities prior to gas service being energized for the application.

.7.5 University Utilities shall witness and approve natural gas pressure testing.

.7.6 If tests indicate work does not meet specified requirements, remove piping, replace piping and retest.

.7.7 Purging of Pipelines: Comply with NFPA 54 for purging of gas lines. Specify that the Contractor shall submit a detailed Purging Plan along with a written request to purge the pipeline to the A/E and University for review, comment, and acceptance 6 weeks prior to the planned purge date. Purging shall be performed by the Contractor in conformance with recommendations of and

under supervision of OSU Utilities and the A/E. Venting during purging operations shall be to the outside of buildings at a safe location.

- .7.8 Interior (House Lines) Gas Distribution: Test, inspect, and purge natural gas lines according to the International Fuel Gas Code, Ohio Administrative Code, and Authorities Having Jurisdiction.

.7.8.1 Existing House Gas Line Testing – specify that this shall be by the Contractor with assistance from OSU Maintenance Staff.

.7.8.1.1 For re-establishing gas service, testing shall be completed using one of the following methods:

.7.8.1.1.1 Pressure Test:

- Test house lines at operating pressure. Minimum test duration shall be specified at a minimum of 3 minutes.
- Test appliance drops at operating pressure. Minimum test duration shall be specified at a minimum of 3 minutes.
- Specify that the operating pressure for existing gas lines shall be measured by the contractor prior to disconnecting any portions of the existing gas system.

.7.8.1.1.2 Dial Test (only applicable when service has been off for less than 30 days and for portions of piping located after the building meter):

- Specify that the contractor shall test the existing gas lines at operating pressure for the minimum duration determined by the smallest graduation on the existing meter listed below:
  - Meter dial cubic feet:  $\frac{1}{4}$  or  $\frac{1}{2}$  = 5 minutes
  - Meter dial cubic feet: 1 = 7 minutes
  - Meter dial cubic feet: 2 = 10 minutes
  - Meter dial cubic feet: 5 = 20 minutes
  - Meter dial cubic feet: 10 = 30 minutes

.7.8.1.2 Specify that natural gas piping will be subject to the Utility Service Connection and Inspection Standards:

[https://fod.osu.edu/sites/default/files/utility\\_service.pdf](https://fod.osu.edu/sites/default/files/utility_service.pdf)

and considered defective if it does not pass tests and inspections.

.7.8.1.3 Specify that the contractor shall prepare all test and inspection reports and submit to the A/E and University for review and acceptance.

## .8 DEACTIVATION AND ABANDONMENT

- .8.1 Specify that all deactivation and abandonment of natural gas piping shall be in accordance with Code of Federal Regulations CFR 192.727. All pipelines deactivated in place must be disconnected from all gas supply sources, purged, and sealed at both ends.

33 51 33 NATURAL GAS UTILITY METERING

.1 GAS SUPPLY METERS

- .1.1 Temporary services shall be metered. Refer to Division One, for metering requirements.
- .1.2 Gas supply to buildings shall be metered for new buildings and major additions and renovations. (Part Four, Facility Services) Meters shall be temperature and pressure compensated when installed upstream of the building pressure regulator and subject to varying supply pressure. Pressure compensating devices shall maintain meter accuracy.
- .1.3 Meters shall conform to the requirements and policies of the utility system providing the gas and AGA as referenced. Meter shall be located in a boiler room or outside of the building. Venting pipes shall be vented to the outside of the building.
- .1.4 Remote registers shall be provided when the meter location prevents direct reading of the meter register from a standing position on grade or finished floor. Remote registers shall be installed at 4' to 5' above grade or finished floor. Remote registers shall be compatible with the installed meter, shall be from the same manufacturer, and shall have a straight reading odometer type display.
- .1.5 Meter shall provide one set of dry contacts that give a pulse output for every 10 cubic feet of usage recorded by the meter.
- .1.6 No battery powered registers, including remote registers, are permitted. Backup battery power is acceptable.
- .1.7 A/E shall design for MODBUS RS-485 communications to give data back to OSU's eDNA. Devices to be specified are as follows but not limited to: NEMA 4X enclosure, B&B Electronics Model MESR901 RS-485 to Modbus TCP/IP converter, Protocol Translator (PT) Board, Sola HD power supply catalog number SDP 5-5-100T, and PULS model ML30.100 24 VDC power supply. A/E shall consult with OSU Utilities during selection and design on these communication devices.
- .1.8 A/E shall provide detailed wiring diagrams in the contract drawings for both meter power and communication connections.
- .1.9 A/E shall specify that meters with fixed pressure factors shall have the pressure factor documented and provided to OSU ESS. Documentation shall be in the form of a calibration certificate.
- .1.10 Easy access shall be provided to meters for maintenance, repairs, and meters shall be flanged and valved to permit convenient replacement of metering.

**33 61 33. HYDRONIC ENERGY DISTRIBUTION METERING**

PART 1 GENERAL

.1 APPLICATIONS

- .1.1 The main objective of this design standard is to outline the specifications of a hydronic energy distribution meter for chilled water and hot water to measure the consumption of energy in total Ton-hours of Refrigeration (Ton-hr), British Thermal Units (BTU), provided to the buildings utilized by The Ohio State University and to communicate this consumption locally and to the



campus-wide Energy Metering & Monitoring system (InStep eDNA server). The hydronic energy distribution meter shall include the instantaneous energy rate in Tons or BTU/hr and totalized energy consumption in Ton-hr or BTU.

- .1.2 The hydronic energy distribution meter, elements and devices, shall meet custody transfer requirements. Custody transfer measurement furnishes quantity and quality information which can be used as the basis for a change in ownership and/or a change in responsibility for materials, e.g., billing for rate of energy demand plus totalized energy transfer.
- .1.3 Products: Describes the general requirements for a totalizing hydronic energy distribution meter, primary element, transmitters, secondary elements, RTD temperature sensors/transmitters, and a flow computer.

.2 DOCUMENTATION

- .2.1 Data sheets and catalog literature for the hydronic energy distribution meter, the transmitters, the RTD temperature sensors/transmitters and the flow computer must be sent to The Ohio State University for evaluation.
- .2.2 Interconnections and drawings for installation of the primary, secondary, and tertiary elements of the corresponding devices shall be submitted for review and approval prior to installation. P&ID's shall be furnished in accordance to ISA S5.
- .2.3 Provide flow computer program setup parameters as written hard copy and as Windows based electronic Adobe Acrobat PDF format file.
- .2.4 Certificates for the conformance of the hydronic energy distribution meter according to engineering procedures and practices, and standards, shall be supplied. Density correction with temperature and pressure for water or glycol solutions, coefficients, linear regressions, constants, equations, methodologies and basis of calculations to establish the energy rates shall be provided.
- .2.5 Certificates of calibration for the hydronic energy distribution meter with water or other liquids available in the calibration facility, as well as a certificate of calibration conformance for the transmitters in accordance to NIST shall be provided.

PART 2 PRODUCTS

.1 PREMISES FOR THE SELECTION OF THE HYDRONIC ENERGY DISTRIBUTION METER AND FLOW COMPUTER

- .1.1 The selection of the hydronic energy distribution meter shall be based on the following parameters and recommendations to guarantee that the accuracy of the hydronic energy distribution meter lies within  $\pm 2\%$ , and the repeatability within  $\pm 1\%$ .
- .1.2 The supply pressure could vary between 60 psig and 120 psig; whereas the supply temperature can vary between 38°F and 180°F and the return temperature can be 5°F to 25°F higher than the supply temperature.
- .1.3 The volumetric flow rate shall be computed in gallons per minute. The flow sensor turndown shall be no less than 15 to 1.
- .1.4 The pressure drop through the primary element, sensor, shall not be greater than 10 inches w.g.c. for the maximum volumetric flow rate.

- .1.5 The flow computer shall provide a 4-20 mA signal for the energy rate in Tons or BTU/hr and / or a pulse signal for the totalized energy consumption in Ton-hr or BTU. The flow computer shall be equipped with a MODBUS TCP/IP RTU communications port or MODBUS RTU RS-485 over AWG-18 twisted pair shielded cable to another meter in the same location. Prior to flow computer approval, the flow computer must be submitted by the Contractor for testing by OSU Utilities to prove interoperability with the campus-wide Energy Metering & Monitoring system (InStep eDNA server) and/or the Utilities Distributed Control System as applicable. Cat-6 shielded cable and conduit shall be installed between the flow computer or group of flow computers connected by twisted pair and the nearest building network switch.
  - .1.6 The flow computer shall provide precise and reliable measurement of absolute and differential pressure, sensor and electronics temperatures, and process temperature from an external RTD. It shall calculate water densities, or glycol solutions according to an appropriate reference source.
  - .1.7 The flow computer shall be supplied with at least 12 feet of AWG-18 shielded twisted pair cable for the RTD input connection. Parameters and measurements shall be stored in non-volatile memory to avoid data loss during power failure. Data shall be restored from internal memory upon restoration of power.
  - .1.8 The flow computer shall be supplied with two isolated outputs that permit external system, e.g. Building Automation Systems, to monitor selected meter parameters.
- .2 PRIMARY ELEMENT, FLOW SENSOR
- .2.1 Magnetic flow element, along with RTDs, which measure supply and return temperatures, shall be used as the primary elements of the hydronic energy distribution meter. The material of the components of the flow sensor and the RTDs must be 316 stainless steel. The nominal size of the sensor shall match the size of the pipe where the flow sensor will be installed. The primary element shall comply with applicable standard codes such as but not limited to ISO, ASME.
  - .2.2 Where applicable, the flow sensor shall be installed in lug type arrangement, constructed of 316 stainless steel rated for 150 psig and 250°F.
  - .2.3 Calculations, equations and/or methodology used to determine the size of the flow sensor shall be supplied to The Ohio State University for acceptance. Where applies, Reynolds Number dependent equations shall be checked for maximum and minimum volume flow rates.
- .3 RESISTANCE TEMPERATURE DETECTOR (RTD) AND TEMPERATURE TRANSMITTER
- .3.1 Furnish a spring-loaded Dual Element 100 ohm platinum RTD temperature sensor assembly. The accuracy shall be  $\pm 0.5\%$  at 32°F utilizing a three-wire single element with aluminum waterproof head and a 316 stainless steel nipple-union-nipple extension. The length shall be determined by the system piping where the meter will be installed.
  - .3.2 The temperature process input range shall be 20°F to 800°F.

- .3.3 The thermo-well shall be 316 stainless steel; long enough for the size of the process piping system with a 4-inch lagging allowance; and provided with a 3/4-inch NPT process connection. The well finish shall be 15Ra maximum, electro-polish finish.
- .4 Certifications
  - .4.1 Calibration and Calculations
    - .4.1.1 A manufacturer's conformance certificate for the calibration of the hydronic energy distribution meter shall be provided.
    - .4.1.2 A certified calculation, for the maximum and minimum volume flow rates at working conditions of temperature, pressure, additive concentration, if present, and pressure shall be supplied.
    - .4.1.3 Calibration of the transmitter(s) shall be accomplished following NIST standards. A certification of conformance shall be submitted.
- .5 Communication
  - .5.1 Meter data in the form of total consumption, flow rate and a meter diagnostic must be communicated over the university Ethernet network back to the InStep eDNA server. Consumption will be in billable units. Meter diagnostic will be in the form of Normal or Failure. MODBUS data registers shall be provided, at a minimum, for instantaneous flow rate, totalized mass value, temperature, pressure, and differential pressure.
  - .5.2 Meters will utilize a combination of MODBUS RTU over RS-485 and MODBUS over Ethernet. A/E shall specify a B&B Model MESR901 RS-485 to Modbus TCP/IP converter for flow computers without built in Modbus TCP/IP.
- .6 Manufacturers
  - .6.1 ABB, Rosemount, Toshiba, or Yamatake magnetic flow meters
  - .6.2 Burns Engineering, or Sensor Tec RTDs.
  - .6.3 Temperature Transmitters are HART SensorTec Model Q4, PR Electronics Model 5335A, or Rosemount Model 248.
  - .6.4 A Kessler-Ellis Products (KEP) flow computer shall be supplied.
  - .6.5 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents.
  - .6.6 All flow meters will be considered for approval on the basis of life cycle cost analysis by the A/E.

### PART 3 EXECUTION

#### .1 WARRANTY

- .1.1 The supplier/manufacturer of the above specified equipment shall guarantee for twenty four (24) months from equipment startup or thirty (30) months from date of shipment, whichever occurs first, that the equipment shall be free from defects in design, workmanship or materials.
- .1.2 In the event a component fails to perform as specified or is proven defective in service during the warranty period, the manufacturer shall promptly repair or replace the defective part at no cost.

- .1.3 The manufacturer or contractor shall furnish OSU Utilities and Energy Services and Sustainability group with an installation, operation and maintenance manual for the energy distribution meter and all its components including a program manual for the flow computer.

.2 INSTALLATION

- .2.1 Follow manufacturer's guidelines and submit installation drawings to OSU Utilities for review and approval prior to installation.
  - 2.1.1 Outages to existing utility systems must be planned and scheduled at least two weeks in advance. See outage procedure:  
[https://ap.osu.edu/sites/default/files/utility\\_outage\\_procedures.docx](https://ap.osu.edu/sites/default/files/utility_outage_procedures.docx)
  - 2.1.2 The Contractor shall obtain assistance from FOD in following the manufacturer's installation specifications such as but not limited to location of the meter components, Ethernet connection, electrical connections, local disconnect, enclosure type, and all other applicable issues.
- .2.2 Power shall be obtained from a dedicated 20 Amp circuit in the nearest local building electrical panel.
- .2.3 The pipe diameter shall be known and shall never be reduced to install the flow sensor.
- .2.4 The location of the components of the hydronic energy distribution meter shall comply with the straight-run pipe upstream and downstream requirements recommended by the manufacturer(s). The straight-run pipe distance shall not be less than 15 times the diameter (15D) of the pipe, 10D upstream and 5D downstream.
- .2.5 Work performed without the assistance of the manufacturer's technical erection supervisor and/or OSU Utilities shall adhere to dimensional requirements, assembly methods, and installation procedures specified herein and in the manufacturer's instruction manuals and drawings.
- .2.6 The Contractor shall comply with all erection and installation methods, techniques, sequence, and procedures requested by the manufacturer's representative and/or OSU Utilities.
- .2.7 Where manufacturer's written instructions differ significantly from those proposed by the manufacturer's representative, OSU Utilities shall determine the method used.
- .2.8 The hydronic energy distribution meter shall be aligned with the direction of the flow in a horizontal line.
- .2.9 Gaskets shall be installed in proper alignment, free of tears and wrinkles. Bolted connections shall be tightened per gasket manufacturer's torque and sequence requirements to provide a uniform tight seal to insure uniform stress over the entire gasket area.
- .2.10 All conduit and conduit connections shall be sealed connections and meet the design and installation standards applicable for the installation area.
- .2.11 Installation services shall include all conduit and wiring to provide a fully functional meter and communication wiring to the building Ethernet switch.

Termination of Ethernet communication cable at the building Ethernet switch shall be by OSU. See Part 2-PRODUCTS; Sections .1.5 and .1.7 (under .1--PREMISES FOR THE SELECTION OF THE HYDRONIC ENERGY DISTRIBUTION METER AND FLOW COMPUTER) for communication and cable requirements.

- .2.12 Panel addressing shall be assigned by OSU Utilities.
  - .2.13 All meters and ancillary equipment shall be installed in such a manner as to provide access for routine inspections, maintenance, and a means of removal.
  - .2.14 The flow computer readout/display shall be located between 5 feet and 6 feet above finished floor level.
  - .2.15 All meters shall be supported independent from the piping systems.
  - .2.16 Structural steel supports and miscellaneous steel required for supporting and/or anchoring meters and piping furnished under this standard shall be provided and installed in accordance with Division 5.
  - .2.17 All anchors and structural steel supports shall be built to template and reinforced as required for loads imposed on them.
  - .2.18 Equipment and pipe internals shall be cleaned and inspected prior to placing in service.
- .3 TRAINING
- .3.1 The supplier/manufacturer shall train OSU Utilities and Energy Services and Sustainability personnel to program, calibrate, operate and maintain the above-mentioned devices for at least 3 hours. Training shall be scheduled within two weeks of completion of the installation.
- .4 INSPECTION AND COMMISSIONING
- .4.1 A representative of OSU Utilities will inspect the installation and performance of the hydronic meter for acceptance and approval before commissioning. OSU Utilities reserves the right to witness factory testing and calibration.
  - .4.2 Provide for review of required closeout documentation.
  - .4.3 Provide for review loop sheets with point to point wiring diagrams in AutoCAD .dwg format.
  - .4.4 Document and provide for review all electrical power sources with breaker and panel numbers.
  - .4.5 Provide for review all calibration data sheets.
  - .4.6 Download or load programming setup parameters.
  - .4.7 The integrity and polarity of all terminations shall be checked and verified.
  - .4.8 All piping connections must pass a service test.
  - .4.9 Final system checks and closeout shall be performed.
  - .4.10 Utility service will not be reinstated by OSU Utilities until installation of the energy distribution meter is inspected by OSU Utilities and found to meet the requirements of the energy distribution meter manufacturer and these design and installation standards.

**33 63 05 GENERAL PIPING PROVISIONS**

PART 1 – GENERAL

.1 RELATED DOCUMENTS

- .1.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- .2 SUMMARY
  - .2.1 This Section includes the following:
    - 2.1.1 Codes conformance
    - 2.1.2 Coordination
    - 2.1.3 Record documents
    - 2.1.4 Maintenance manuals
    - 2.1.5 Cutting and patching
    - 2.1.6 Installation of equipment
    - 2.1.7 Grout
- .3 SUBMITTALS
  - .3.1 Product Data and Shop Drawings: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
    - 3.1.1 Grout product data
    - 3.1.2 Hot –dip galvanizing process data and galvanizing repair paint data
    - 3.1.3 Shop drawings for metal fabrications for piping equipment and pipe supports
    - 3.1.4 Coordination Drawings
  - .3.2 Project Record Documents: In accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS, submit the following:
    - .3.2.1 Red line drawings
- .4 CODE CONFORMANCE
  - .4.1 Codes include but are not limited to:
    - .4.1.1 State Power Piping Code
    - .4.1.2 ASME Power Piping Code B31.1
- .5 QUALITY ASSURANCE
  - .5.1 Equipment and appurtenances shall be designed in conformity with ANSI, ASME, IEEE, NEMA, OSHA, AGMA, ASTM, and other generally accepted applicable standards.
  - .5.2 All machinery and equipment shall be safeguarded in accordance with the safety codes of the ANSI, OSHA, and local industrial codes, including but not limited to, shaft guards on all rotating shafts, cages around exposed fan blades, etc.
  - .5.3 All mechanical work shall be performed by mechanics who are qualified to do such work and who are normally engaged in this type of work.
- .6 PROJECT PIPING WORK REQUIREMENTS AND COORDINATION
  - .6.1 The project requires piping systems to be fully coordinated and integrated. The piping systems shall be designed and installed to comply with the ASME B31.1 Power Piping Code. The Contractor shall coordinate requirements for

fully integrated piping systems that utilize and are comprised of pipe expansion joints, pipe expansion loops, pipe supports, pipe anchors, valves, specialties, and pipe insulation. Coordination drawings shall be provided demonstrating compliance with ASME B31.1 for all piping systems. The Coordination drawings shall indicate all piping system requirements including pipe thermal expansion and contraction axial and lateral travel, pipe support criteria, pipe anchor placement, expansion joint requirements, and similar items.

- .6.2 Coordinate requirements for cast-in-place concrete embedded anchor bolts for pipe anchors and similar components with other trades.

## PART 2 – PRODUCTS

### .1 MATERIALS

- .1.1 General: Materials shall be new and shall conform to the materials specified on the Contract Drawings and as follows:

- .1.1.1 Shim stock used in leveling and alignment shall be Type 304 stainless steel.

- .1.1.2 Leveling plates and blocks shall conform to ASTM A 36. Steel plate stock with a thickness of 1/2-inch or less shall have sheared edges; thicker stock may be flame cut with burrs removed.

- .1.1.3 Grout shall be an approved premixed, prepackaged, non-shrink grout which requires only the addition of water. Grout shall be non-shrink, nonmetallic, and in accordance with ASTM C 1107, Grade B.

- .1.1.3.1 Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications

- .1.1.3.2 Design Mix: 5000 psig, minimum 28-day compressive strength.

- .1.1.3.3 For high temperature applications at HPS and PC anchors, use Five Star HTR Grout by Five Star Products, Inc. Grout at HPSS and PCR pipe slide and guide locations shall be non-high temperature rated.

- .1.1.4 Metal fabrications and fasteners for pipe supports and anchors shall be provided in accordance with the drawings and specifications Section 05 50 00 – METAL FABRICATIONS with the following exceptions:

- .1.1.4.1 Structural Steel Plates and Bars shall conform to ASTM A36.

- .1.1.4.2 Structural Steel Shapes shall conform to ASTM A36.

- .1.1.4.3 Anchor Rods, bolts and washers shall be carbon steel ASTM F1554 grade 55.

- .1.1.5 Metal fabrications, anchors, pipe supports, embedded anchor rods and similar items shall be galvanized unless indicated otherwise. Galvanizing shall be by the Hot-dip process complying with ASTM A123 or A153. Galvanizing repair paint shall be field applied for

touch-up on field welds and similar finish repairs. Galvanizing repair shall comply with ASTM A780. Cold Galvanizing repair paint shall contain 95% zinc dry and shall have a temperature resistance of 350°F continuous and 750°F intermittent. Cold galvanizing is not required where welds are to be covered with insulation.

- .1.1.6 Expansion anchors and high strength bolts, nuts and washers shall be zinc plated as per Section 05 50 00 – METAL FABRICATIONS.

### PART 3 – EXECUTION

#### .1 COORDINATION

- .1.1 It is the responsibility of the Contractor to coordinate the work of his trade with all other trades prior to the commencement of construction and during construction. It is the responsibility of the Contractor to provide, in his original bid, all necessary offsets, fittings, and transformations to provide a complete project. Any conflicts must be brought to the attention of the A/E. Any work requiring removal and reinstallation due to the lack of coordination shall be the responsibility of the Contractor with no additional cost to the University.
- .1.2 Refer to Part 1-General, Paragraph .6.1.
- .1.3 Coordinate requirements for cast-in-place concrete embedded anchor bolts for pipe anchors and similar components with other trades.
- .1.4 During coordination meetings, discuss amongst the contractors scheduling, sequencing, movement, and positioning of large equipment during construction. Refer to Section 01 31 00 – PROJECT MANAGEMENT AND COORDINATION.

#### .2 MAINTENANCE MANUALS

- .2.1 Prepare maintenance manuals in accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS. Include the following information for equipment items:
  - 2.1.1 Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
  - 2.1.2 Manufacturer's printed operating procedures to include start up, break in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
  - 2.1.3 Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
  - 2.1.4 Servicing instructions and lubrication charts and schedules.
  - 2.1.5 One complete set of non-reproducible (white print or blue print) as-built drawings.
  - 2.1.6 A copy of all of the satisfactory reviewed submittals.

#### .3 INSPECTION



- .3.1 Prior to performing work required under Division 33 carefully inspect all existing conditions and the installed work of all other trades and verify that all conditions and all such work is complete to the point where the work may properly commence.
- .3.2 In the event of discrepancy, immediately notify A/E and UTHQ. UTHQ shall perform the piping inspections on behalf of the University, not ODIC.
- .4 QUALITY ASSURANCE
  - .4.1 Ample clearance shall be provided for repairs, inspection and adjustment. Protruding members such as joints, corners and gear covers shall be finished in appearance. All exposed welds shall be ground smooth and the corners of structural shapes shall be rounded or chamfered.
  - .4.2 Secure and pay for all necessary fees, permits, inspections and approvals, as required for the work of Division 33 specifications.
- .5 CUTTING AND PATCHING
  - .5.1 Perform cutting, fitting, and patching of piping equipment and materials required to:
    - .5.1.1 Uncover Work to provide for installation of ill-timed Work.
    - .5.1.2 Remove and replace defective Work.
    - .5.1.3 Remove and replace Work not conforming to requirements of the Contract Documents.
    - .5.1.4 Remove samples of installed Work as specified for testing.
    - .5.1.5 Install equipment and materials in existing structures.
  - .5.2 A/E shall specify that the contractor shall perform in accordance with the Project's Cutting and Patching specification section in Division 01.
- .6 PERFORMANCE
  - .6.1 Perform all work that is essential in completing the intended installation in the proper manner.
  - .6.2 Field verification of all dimensions is required.
  - .6.3 Wherever obstructions are encountered in the path or course of the work that are not shown nor anticipated in the Contract Documents, do not proceed with the installation of the work before advising the A/E and receiving detailed information or drawings or both.
- .7 INSTALLATION OF EQUIPMENT, SPECIALTIES AND SUPPORTS
  - .7.1 All equipment shall be installed true, level and in the location shown on the Drawings to within  $\pm 0.002''$ . Precision gauges and levels shall be used in setting all equipment.
  - .7.2 Furnish, install and protect all necessary guides, bearing plates, anchor and attachment bolts, and all other appurtenances required for the installation of equipment.
  - .7.3 All equipment shall be installed in such a manner as to provide access for routine maintenance, including lubrication.

- .7.4 All equipment piping shall be routed from previously-set equipment to reduce any pipe strain.
  - .7.5 Structural steel supports and miscellaneous steel required for supporting and/or hanging equipment and piping furnished under this Division shall be provided and installed in accordance with section 05 50 00 – METAL FABRICATIONS.
  - .7.6 All anchors and structural steel supports shall be built to template and reinforced as required for loads imposed on them.
- .8 INSTALLATION
- .8.1 Technical Erection Supervision:
    - .8.1.1 Work performed without the assistance of the manufacturer's technical erection supervisor shall adhere to dimensional requirements, assembly methods, and installation procedures specified herein and in the manufacturer's instruction manuals and drawings.
    - .8.1.2 The Contractor shall comply with erection and installation methods, techniques, sequence, and procedures requested by the manufacturer's representative, if the manufacturer's representative is present.
    - .8.1.3 Where manufacturer's written instructions differ significantly from those proposed by the manufacturer's technical erection supervisor, the A/E shall determine the method to be used.
  - .8.2 Manufacturer's Drawings and Instruction Books: Manufacturer's drawings and instruction books for University-furnished equipment and materials to be installed will be made available to the Contractor. Upon completion of the Work, all instruction books shall be returned to the University.
  - .8.3 Pre-installation Requirements:
    - .8.3.1 Protection:
      - .8.3.1.1 The Work, material, and equipment installed by the Contractor shall be adequately covered and protected against dirt, water, frost, chemical, and mechanical damage. The Contractor shall make good, at his own expense by repair or replacement as directed by the University and by using approved equivalent materials, any and all damages to equipment or buildings caused directly or indirectly by his workmen, workmanship, or by his failure to properly protect his Work.
      - .8.3.1.2 Equipment that may be damaged by freezing shall be checked to insure that all water has been drained from the unit prior to placing the equipment in storage or on its foundation.
      - .8.3.1.3 The shafts of assembled rotating equipment shall be rotated a minimum of once per week while in storage, unless the manufacturer's instructions advise otherwise.

- Bearings shall be checked to insure lubrication prior to rotating.
- .8.3.1.4 Material shall not be stacked or piled on finished surfaces unless the surfaces are positively protected by substantial wooden covers rigidly secured in place. Finished bottom surfaces shall be set only on clean, dry wooden dunnage.
  - .8.3.2 Cast-in-place embedded anchors: Cast-in-place anchors shall be checked to determine that there are no errors in anchor bolt locations and projections from that shown on the Drawings or otherwise required. The University shall be notified if any cast-in-place embedded anchors are determined to be defective or incorrect.
  - .8.3.3 Cleaning:
    - .8.3.3.1 Protective coatings, shipping protection, oil, grease, and loose material shall be removed from the surfaces of the equipment.
    - .8.3.3.2 Just prior to assembly, all finished surfaces shall be uncovered and thoroughly cleaned of loose paint, foreign matter, and rust. Rust shall be removed by means of a high-grade rust remover applied with lint-free cloths.
    - .8.3.3.3 The underside of all equipment shall be cleaned of all dirt, oil, grease, and loose material. Foundation anchor bolts shall be straightened and the threads rerun with a suitable die prior to setting the equipment on its foundation.
  - .8.4 Equipment Handling: Proper and adequate handling equipment and rigging shall be used at all times. Equipment and rigging shall be examined and checked at frequent intervals. The weights and dimensions of the equipment shall be obtained from the manufacturer's drawings, as required, to insure the use of adequate equipment.
  - .8.5 Leveling: Leveling shall comply with the manufacturer's leveling instructions or with the following procedure where the manufacturer's instructions are not available:
    - .8.5.1 Equipment, supports and specialties shall be lowered over anchor bolts holding the underside of the base a minimum of 1 inch above the surface of the foundation (unless indicated otherwise) to allow adequate space for grouting.
    - .8.5.2 Units equipped with leveling screws: Rectangular steel leveling blocks shall be placed on the foundation close to and straddling each foundation bolt. Additional steel leveling blocks shall be placed directly under all parts of base which carry direct heavy loads. Leveling blocks shall be placed close enough to give uniform support and shall not project excessively beyond the edge of the base. Each block shall rest solidly on good concrete.

- .8.5.3 With the unit resting on leveling blocks, the unit shall be adjusted to alignment and elevation established by the Drawings. Level shall be checked in both directions with a precision level.
- .8.5.4 Shims shall be installed, as required, to maintain even weight distribution on all leveling blocks. In building up shim height, thickness shall be selected to minimize the number of shims required. If wedges are used in adjusting elevation, the base shall be supported in the final level position entirely by the leveling blocks and not partially by wedges.
- .8.5.5 Level of base shall be determined by use of accurate precision spirit levels, resting wherever possible on leveling pads or clean, finished surfaces. Painted surfaces shall not be used as a datum for checking level.
- .8.5.6 When the unit has been satisfactorily leveled in all directions, the foundation bolts and nuts shall be drawn down tight.
- .8.6 Gaskets: Gaskets shall be installed in proper alignment, free of tears and wrinkles. Bolts shall be tightened evenly all around to insure uniform stress over the entire gasket area. Refer to Section 33 63 45 – GASKETS.
- .8.7 Grouting of Equipment, Supports and Specialties:
  - .8.7.1 Equipment, supports and specialties shall be grouted as specified herein. The premixed grout shall be delivered to the site in the manufacturer's original container. Each package of premixed grout shall be accompanied by printed instructions from its manufacturer for mixing, placing, and curing and shall include temperature limitations for use of the grout.
  - .8.7.2 Mixing: Premixed grout shall be mixed in accordance with the manufacturer's instructions. The water-to-grout ratio shall not exceed that shown on the manufacturer's test results for the desired strength. Water mixed with grout shall be a minimum and shall not exceed the quantity required to place the grout.
  - .8.7.3 Before grouting, the A/E's written approval shall be obtained to proceed with each piece of equipment. Unless specified otherwise, the equipment to be grouted shall be in place on its foundation, leveled, aligned, and completely assembled.
  - .8.7.4 Rigid connections to equipment shall not be made until grout has been placed and allowed to cure for a minimum of 5 days.
  - .8.7.5 Surface Preparation and Forms:
    - .8.7.5.1 The surface of the concrete shall be either bush hammered or chipped to present a sound, rough surface free of laitance, oil, and other contamination.
    - .8.7.5.2 The baseplate undersurface shall be cleaned of loose rust, mill scale, oil, grease, and other foreign materials before being set into place.
    - .8.7.5.3 The concrete surface anchor bolt holes shall be thoroughly saturated by being maintained visibly wet for 24 hours immediately before grout is placed. Standing water,

including water in anchor bolt holes, shall be removed before grout is placed.

.8.7.5.4 Formwork shall be fixed around each baseplate to the level of the top of the plate or to above the level of high, trapped areas under the plate, whichever is higher. Forms on the pouring side of the plate shall be raised to provide a sufficient head for the grout to flow under the plate. Forms shall be caulked on the inside to prevent leakage, using the same grout material as is to be poured but mixed to a plastic consistency.

.8.7.6 Placement of Grout:

.8.7.6.1 Anchor bolt holes shall be filled first. If interference from formwork is anticipated, anchor bolt holes may be filled a day or two in advance, provided presoaking of the concrete is resumed as soon as the holes have been filled.

.8.7.6.2 Grout shall be poured from only one side of the plate, starting at one corner and moving across the same side to the other corner, until the entire space is filled and the grout is visible on the opposite side at the top of the plate.

.8.7.6.3 The grout mix can be preserved during short pauses in pouring by working it with flat steel straps (not chains) preferably inserted from pouring side.

.8.7.6.4 Grout shall not be placed when the temperature of air, plate, or foundation concrete is below 45°F or the temperature specified by the manufacturer, whichever is higher. The temperature of the grout shall be maintained at a minimum of 45°F or in accordance with the manufacturer's instructions, whichever is higher, for 24 hours after the grout has been placed. Thereafter, it shall be maintained above freezing until the grout has attained a compressive strength of 3000 psi or for 6 days, whichever occurs first.

.8.7.6.5 If the ambient temperature exceeds 80°F, the baseplate and concrete shall be cooled by means such as shading and placing soaking burlap on the baseplate before grouting is begun.

.8.7.6.6 Whenever sufficient handling and placing time is desired at ambient temperatures near 80°F, iced mixing water may be used in place of some of the batch water to extend the usable life of the grout, provided the temperature of the grout after mixing is not below 45°F. The total of water plus ice shall not exceed the mix design water content.

.8.7.7 Finishing and Curing: Grout shall be cured as follows, unless the manufacturer recommends otherwise:

- .8.7.7.1 As soon as grout reaches initial set (such that grout is not damaged by wet cloth or burlap), all exposed surfaces shall be covered with cloth or burlap which shall be maintained constantly wet until forms are stripped to prevent moisture loss from grout. When multiple lifts are used, the grout shall be covered with wet cloth or burlap for 48 hours after each lift.
- .8.7.7.2 When grout has thickened sufficiently to be troweled, any excess grout that has spilled over and accumulated on top of the plate shall be removed until grout is flush with the top of the plate. The curing cloth may be removed temporarily for this purpose.
- .8.7.7.3 Forms shall not be removed nor grout disturbed below the level of the underside of the plate until grout is sufficiently hard that it cannot be penetrated by the point of a hand-held trowel.
- .8.7.7.4 After removal of forms, the exposed edges of the grout shall be chamfered or bull-nosed and all exposed surfaces coated with curing compound.
- .8.7.7.5 Unless the Drawings indicate otherwise, shims shall remain in place for at least 48 hours after completion of the grouting and then shall be removed. After removal of shims (or screws), voids shall be filled or back-packed with grout.
- .8.7.8 Rechecking Level and Alignment after Curing Grout:
  - .8.7.8.1 After grout has cured a minimum of 5 days and after rigid connections have been made, level and alignment of the equipment shall be checked completely, and all adjustments necessary to correct level and alignment shall be made.
  - .8.7.8.2 Where possible, shims required for adjustments between component parts of the equipment shall be installed without disturbing the bond between the grout and under the surface of the equipment base.
  - .8.7.8.3 Where the necessary level and alignment adjustments require breaking of the bond between the equipment base and grout, the original grout shall be removed and the base re-grouted after completion of leveling and alignment.
- .8.7.9 Securing Anchor Bolts: The anchor bolt nuts shall be tightened securely, after confirmation of correction of equipment level and alignment on the grout, in accordance with manufacturer's torque requirements. Leveling screws shall be backed off at this time so that equipment is supported on the grout. If the manufacturer's torque requirements are not provided, the foundation bolt nuts shall be tightened to the following minimum torque requirements:
  - 1/2-inch dia            15 lb-ft
  - 5/8-inch dia            25 lb-ft

- 3/4-inch dia      40 lb-ft

.8.8 Doweling: Doweling, where required by manufacturer's drawings and instructions or where directed by the A/E, shall be installed only after hot and cold initial operation of equipment, unless the manufacturer's instructions advise otherwise. The holes shall be drilled and reamed, as necessary, to install the dowels.

.9 CLEANING

.9.1 Cleaning and Flushing Installation:

.9.1.1 Equipment and pipe internals shall be cleaned, inspected and flushed prior to placing in service. Chilled water piping systems shall be flushed with water and an approved cleaning solution. Refer to Section 33 63 10 – COMMON WORK RESULTS FOR PIPING for additional pipe cleaning and flushing requirements.

.9.1.2 The Contractor shall be responsible for any damage to equipment and piping caused by dirt, chips, and any foreign materials.

33 63 10 COMMON WORK RESULTS FOR PIPING

PART 1 – GENERAL

.1 RELATED DOCUMENTS

.1.1 Contract Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to work of this Section.

.1.2 Requirements of the following Specification Sections apply to this Section:

.1.2.1 Piping materials and installation methods for each pipe group are specified as subsections of this Section.

.1.2.2 Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT

.1.2.3 Section 33 63 25 - PIPING SPECIALTIES

.1.2.4 Section 33 63 45 – GASKETS

.1.2.5 Section 33 63 20 – METERS AND GAUGES

.1.2.6 Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

.1.2.7 Section 33 63 55 - PIPING INSULATION

.2 DESCRIPTION OF WORK

.2.1 This Section specifies piping materials and installation methods common to more than one section of Division 33 and includes basic piping installation instructions. This Section covers piping that falls under the ASME B31.1 Power Piping Code. Refer to Division 33 Drainage System Sections for drainage piping and related work that falls under ASME B31.9 and local codes.

.2.2 Types of pipes and pipe fittings specified in this Section include the following:

.2.2.1 Steel Pipes

.2.2.2 Stainless Steel Pipes

.2.2.3 Copper Pipes

.2.2.4 Miscellaneous Piping Materials/Products

- .2.3 Pipes and pipe fittings furnished as part of factory-fabricated equipment are specified as part of the equipment assembly in other Division 33 Sections and in general shall comply with the requirements of this Section.

.3 SUBMITTALS

- .3.1 Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
  - .3.1.1 Manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting
  - .3.1.2 Piping schedule showing manufacturer, ASTM number, ASTM type, ASTM grade, pipe or tube weight, fitting type, and joint type for each piping system
  - .3.1.3 The piping and accessories submittal shall clearly describe what components are going to be used for each piping group.
  - .3.1.4 Records and reports required for certain pipe groups as specified in individual piping group specifications
  - .3.1.5 Provide ISO 9001 and Independent Test Reports if applicable per Quality Assurance paragraph below.
  - .3.1.6 "Fire Watch" safety procedures
- .3.2 Maintenance Data: In accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS submit the following:
  - .3.2.1 Maintenance data and parts lists for each type of mechanical fitting.
- .3.3 Quality Control Submittals: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
  - .3.3.1 Installers Qualification Data:
    - .3.3.1.1 Welder Qualification Data: Copies of certification; include names, home addresses and identification numbers of welders.
    - .3.3.1.2 Welding Procedures: Shall include QW-482 "Suggested Format for Welding Procedure Specification (WPS)" and QW-483 "Suggested Format for Procedure Qualification Record (PQR)" as specified in Welding Quality Assurance below for different weld types.
    - .3.3.1.3 Welders' Certificates: Shall include QW-484 "Suggested Format for Manufacturer's Record of Welder or Welding Operator Qualification Tests (WPQ)" for all welders for all weld types as specified in Welding Quality Assurance below.
    - .3.3.1.4 Welder Identification List
  - .3.3.2 Manufacturer's Data: Copy of mill certificates, laboratory test and manufacturing reports relating to chemical and physical properties of pipe, fittings, and related materials.
  - .3.3.3 Independent Testing Agency Qualifications: As specified in this Section.



- .3.3.4 ISO 9001 and Independent Test Reports: As specified in Quality Assurance below.
- .3.4 Piping Tests: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
  - .3.4.1 Hydrostatic Testing Records: The Contractor shall maintain a constantly updated log (as described in this Section) available to the University and A/E at all times. The Contractor shall submit a final log to the A/E for his records.
  - .3.4.2 Visual Examination Examiner's Qualifications: Provide as specified in this Section.
  - .3.4.3 Visual Inspection Reports: Provide as specified in this Section.
  - .3.4.4 Radiography Examination Written Procedure: Provide as specified in this Section.
  - .3.4.5 Radiography Examination Reports: Provide as specified in this Section.
  - .3.4.6 Radiography Examination Examiner's Qualifications: Provide as specified in this Section.
  - .3.4.7 Independent Testing Agency Information: The Contractor and the independent testing agency shall provide a signed statement that the testing agency has no affiliation with the Contractor and can serve as an independent agency to provide the testing as specified.
  - .3.4.8 Welder Identification List: Provide as specified in this Section.
- .4 QUALITY ASSURANCE
  - .4.1 Codes and Standards:
    - .4.1.1 All piping systems with the exception of potable city water, sanitary, and other plumbing systems piping shall be designed, fabricated, erected, and tested in accordance with ASME B31.1.
    - .4.1.2 All welders performing welding to this procedure shall be qualified to this procedure in accordance with ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications."
    - .4.1.3 Conform to ASME Boiler and Pressure Vessel Code and ASME B31.1 Power Piping Code for administrative and technical requirements for Boiler External Piping and Non-boiler External Piping.
    - .4.1.4 Comply with the latest editions of the publications of the following Agencies to the extent referenced in this Section:
      - ANSI - American National Standards Institute
      - API - American Petroleum Institute
      - ASME - American Society of Mechanical Engineers
      - ASTM - American Society for Testing and Materials
      - AWS - American Welding Society
      - AWWA - American Water Works Association
      - CISPI - Cast Iron Soil Pipe Institute Association
      - FM - Factory Mutual
      - NFPA - National Fire Protection Association
      - PFI - Pipe Fabrication Institute

- UL - Underwriter's Laboratories, Inc.

.4.2 Special Precautions

- .4.2.1 Torch cutting will be permitted only with the specific written approval of the University. Any cutting method, which may create sparks, must include "Fire Watch". Submit "Fire Watch" procedure for approval. Obtain and use the "Hot Work" forms from OSU; the Hot Work form can be provided by the Office of Environmental Health and Safety (EHS) or from OSU Utilities Manager of Support Services. Make sure the plan contains contact names and phone numbers, end of work plan, posting of emergency contact numbers, fugitive emissions control, ventilation for welding and shutdown of exhaust fans in case of fire, and procedures that are specific to this project.
- .4.2.2 Draining operations must not damage building components or endanger human health.

.4.3 Country of Fabrication:

- .4.3.1 All piping, fittings, and piping accessories not manufactured, fabricated, and/or assembled in the United States of America or Canada must be manufactured, fabricated, and/or assembled by an ISO 9001 registered corporation.
- .4.3.2 Submit ISO 9001 registration certificates for all corporations where the piping, fittings, and piping accessories are not manufactured, fabricated, and/or assembled in the United States or Canada.
- .4.3.3 For all piping, fittings, and piping accessories not fabricated in the United States or Canada, submit an independent test report for all materials to be provided.
- .4.3.4 No piping, fittings, and piping accessories manufactured, fabricated, and/or assembled in China including Taiwan are permitted to be provided in this Contract.

.5 WELDING QUALITY ASSURANCE

- .5.1 Welding Procedures: In the form of a submittal, the Contractor shall record in detail and shall qualify the Welding Procedure Specifications for every welding procedure that he proposes. Procedures shall be developed for all metals included in the work. The procedures for making transition welds between different materials or between plates or pipes of different wall thickness shall be qualified. Qualification for each welding procedure shall conform to the requirements of ASME B31.1, and to this specification. The method for each system shall be fully described including the number of beads, the volts, the amperes, and the welding rod for various pipe thicknesses and materials. The welding procedures shall specify end preparation for butt welds including cleaning, alignment, and root openings. Preheat, interpass temperature control, and post-heat treatment of welds shall be as required by approved welding procedures, unless otherwise indicated or specified. Approval of any procedure does not relieve the Contractor of the sole responsibility for

producing acceptable welds. Welding procedures shall be identified individually and shall be clearly referenced to the type of welding required for this project. These procedures shall be the same as those used for all pipe welder qualification tests, all shop welds, and all field welds. The Contractor shall provide Procedure Qualification Records for all proposed Welding Procedure Specifications (WPS).

.5.2 Welding Procedure Submittals: Submit the following:

.5.2.1 Welding Procedure Specifications: Provide for each weld type. It is highly recommended that the Contractor use ASME Form E00006, QW-482 "Suggested Format for Welding Procedure Specification (WPS)".

.5.2.2 Procedure Qualification Records: Provide for each weld type. It is highly recommended that the Contractor use ASME Form E00007, QW-483 "Suggested Format for Procedure Qualification Record (PQR)".

.5.3 Welder Qualification:

.5.3.1 WPQs: Provide welder qualifications for each welder for each weld type. It is highly recommended that the Contractor use ASME Form E00008, QW-484 "Suggested Format for Manufacturer's Record of Welder or Welding Operation Qualification Tests (WPQ)." The WPQs shall be performed under the witness of an independent agency. The witness shall be a representative of an independent testing agency, Authorized Inspector, or consultant, any of which must be approved by the National Certified Pipe Welding Bureau. The qualifying test segment must be a 2 inch nominal pipe size with wall thickness within range of the WPS. Tests position shall be "6G" per ASME Section IX.

.5.3.2 Evidence of Continuity: Welder qualifications must be current. If the qualification test is more than 6 months old, provide record of welding continuity for each welder. Record of welding continuity shall show that the welder in question has performed welding to the procedure in question without a 6-month continuous span of inactivity since the date that the welder qualification test was passed for the submitted welding procedure. Record of welding continuity shall include, at a minimum, the welder's employer name and address, the date the welder qualification test was passed, and the dates indicating welding continuity including welding procedure for each date.

.5.4 Weld Records:

.5.4.1 For all welding within the scope of ASME B31.1, the Contractor shall submit for approval an administrative procedure for recording, locating, monitoring, and maintaining the quality of all welds to be performed on the project. This quality control document record shall include but not be limited to drawings and schedules identifying location of each weld by individual number,

identification of welder who performed each weld by individual welder's name, stamp number, date and WPS used.

.5.4.2 After achieving qualification, but before being assigned work, each qualified person shall be assigned an identifying number by the Contractor that shall be used to identify all of his welds. A list of qualified persons with their respective numbers shall be submitted by the Contractor and shall be maintained accurately with deletions and additions reported promptly.

.5.4.3 Upon completing a joint, the welder shall mark the pipe not more than 6 inches from the weld with the identifying number and the last two digits of the year in which the work was performed. Identification marks shall be made by using a rubber stamp or felt-tipped marker with permanent, weatherproof ink or other methods approved by the A/E that do not deform the metal. For seam welds, identification marks shall be placed adjacent to the welds at 3-foot intervals. Identification by die stamps or electric etchers will not be allowed. The markers are to be provided by the Contractor. Substituting a map of welds with welders' names shall not be acceptable.

.5.5 Welder Pre-Qualification

.5.5.1 All welders shall be pre-qualified for this project by having the first weld tested via radiographic (RT) method by the independent testing agency (ITA), whose services shall be paid for by the Contractor. Acceptance standards shall be in accordance with Paragraph 136.4.5 of ASME B31.1. The procedure shall be in accordance with Article 2 of Section V of the ASME Boiler and Pressure Vessel Code. The ITA shall submit the written procedure as described in Paragraph T-221 of Article 2 of Section V of the ASME Boiler and Pressure Vessel Code. The ITA shall provide a report in accordance with Paragraph T-291 of Article 2 of Section V of the ASME Boiler and Pressure Vessel Code. All persons performing and evaluating radiographic examinations shall be certified for NDT Level II RT as recognized by the ANST. A nationally certified Level III RT technician per ANST shall be on staff at the testing laboratory. A Corporate Level III RT without National Certification is not acceptable. Welders shall do one weld and then have that weld tested and approved via RT before doing any more welding work. Maintain an active approved list with the University.

.6 DELIVERY, STORAGE, AND HANDLING

.6.1 Piping material shall be packaged in accordance with ASTM A 700 and as specified herein.

.6.2 Pipe Storage: Upon the receipt of each shipment of pipe on the job, the Contractor is responsible for maintaining the marking and for the storage of all pipe in such a manner that the ASTM material specifications and method of manufacture (seamless, etc.) of each piece of pipe will be clearly discernible at

- the time of its installation in the system. If at the time of its installation any piece of pipe is not readily identifiable, it will be subject to rejection, or arbitrary downgrading by the A/E to the lowest grade which has been received on the job to that date.
- .6.3 Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, and clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
  - .6.4 Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.
  - .6.5 Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.
  - .6.6 Austenitic Stainless Steel Material: The following shall apply to handling, fabrication, and storage of austenitic stainless steel piping, tubing, and material to prevent surface contamination:
    - .6.6.1 Care shall be taken when handling stainless steel piping and tubing to minimize contact with carbon steel.
    - .6.6.2 Stainless steel material shall be protected against contact with lead, zinc, copper, and other low melting point materials.
    - .6.6.3 Tube cutters, grinding wheels, brushes, and files used to work on stainless steel material shall not have been previously used on other material.
    - .6.6.4 Brushes used on stainless steel shall have stainless steel bristles.
    - .6.6.5 Grinding wheels used on stainless steel shall be resin-bonded aluminum oxide or silicon carbide.
    - .6.6.6 Cutoff saws may be used on stainless steel material without special precautions, where followed by a grinding or machining operation.
    - .6.6.7 Carbon steel packing bands shall not be used in direct contact with stainless steel piping and tubing.
    - .6.6.8 Nylon slings shall be used in handling stainless steel material.
  - .6.7 External machined surfaces, flange facings, and bolt holes shall be protected against corrosion during shipment, storage, and installation with the application of one coat of water-soluble, rust-inhibiting coating.
  - .6.8 All edges prepared for field welding shall be protected against corrosion during shipment, storage, and installation with one coat of rust-inhibiting coating (deoxaluminated or University-approved equivalent) applied after inspection and cleaning.

## PART 2 - PRODUCTS

### .1 GENERAL

- .1.1 Code: The fabrication and erection of all applicable piping shall conform to the latest edition and all current revisions of ASME Code for Power Piping B31.1. In addition, the fabrication and erection of all piping shall conform to all applicable Federal, State, and Local laws.

- .1.2 Piping Materials: Provide all pipe and tube of type, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by the intended service use, comply with governing regulations and industry standards, and obtain approval from the A/E prior to any work.
  - .1.3 Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections as determined by the intended service use and install in accordance with pipe manufacturer's recommendations. In addition, obtain approval from the A/E before performing any work.
  - .1.4 All materials shall be submitted for review prior to being incorporated in the Work. Material for pipes, fittings, and accessories shall be new and in accordance with ASTM specifications. Welded attachments shall be made of material compatible with the piping. Where the material for a specific component is not specified, it shall be selected by the Contractor for review by the A/E. Material and equipment specified by brand or manufacturer are typical and designate the type, quality, and purpose of the items. Similar and equivalent items of equal standards may be accepted if, in the opinion of the A/E, they are equivalent in all important respects and are equally suitable for the purpose intended. The Contractor shall submit descriptive literature and secure the A/E's written approval for any substitutions before orders are placed.
- .2 PIPE IDENTIFICATION SYSTEM
- .2.1 General: A system has been established which identifies the specific piping materials and, insulation, gaskets, and other components for each type of pipe identified in the Contract Drawings. The specific pipe specification is linked by the service number as listed in the "Piping, Gasket, Insulation, and Service Group Index", which appears in this Section.
  - .2.2 Pipe Identification System Description: The system used on the Contract Drawings to indicate the specific materials and construction required for each pipe line is illustrated by the following example.
    - .2.2.1 A typical pipe line may be called out as:  
 10" HPS, where:
      - 10": Indicates nominal pipe size of line
      - HPS: Is the abbreviation for the piping system contents and is the service group as depicted in the "Piping, Gasket, Insulation and Service Group Index". In this example the abbreviation is for Steam, High Pressure. In this example, the service group "HPS" requires Pipe Group 3, and Gasket Group "HP."
      - Gasket groups are specified in detail in Section 33 63 45 - GASKETS.
      - Pipe material and erection specification groups appear as subsections of this Section. For example in the above example the service group is "HPS" which according to the index

corresponds to Pipe Group 3; refer to Section 33 63 10.20 PIPING GROUP 3 - CARBON STEEL - HIGH PRESSURE STEAM PIPE-HPS for the material and erection specification of this pipe line.

- Valve groups are identified and specified in Section 33 63 35 – VALVES.
- Insulation groups are specified in detail in Section 33 63 55 - PIPING INSULATION.

.3 PIPING, GASKET, INSULATION, AND SERVICE GROUP INDEX: THE FOLLOWING PAGES CONTAIN THE "PIPING, GASKET, INSULATION, AND SERVICE GROUP INDEX".

**PIPING, GASKET, INSULATION, AND SERVICE GROUP INDEX**

SERVICE	LINE DESCRIPTION & DESIGN CONDITIONS	PIPE GROUP	GASKET GROUP	SERV GROUP ON DWGS
EQUIPMENT DRAIN, PUMPED	50 PSIG at 212°F Max, from Sump Pump Discharge in Trenches	90	HP	PED
CONDENSATE, HIGH PRESSURE	200 PSIG at 600°F Max., from HPS to PC System	94	HP	HPR
CONDENSATE, PUMPED	200 PSIG at 388°F Max., Returned Condensate from Campus and Manhole Pumps to Plant	94	HP	PCR
STEAM, HIGH PRESSURE	200 PSIG at 600°F Max., HPS Campus Distribution	<u>3</u>	HP	HPS
CHILLED WATER SUPPLY AND RETURN	100 PSIG at 140°F Max, chilled water return from/to chiller plants and buildings	2	HPB	CWS & CWR

.4 IMPULSE LINES

.4.1 Impulse lines for pressure gauges shall be per Piping System Specification of the PIPE GROUP as identified in the table shown in .3 PIPING, GASKET, INSULATION, AND SERVICE GROUP INDEX. However, regardless what is specified, impulse line for steam systems shall be socket-welded Schedule 80 ASTM A106 Seamless Carbon Steel.

**PART 3 – EXECUTION**

.1 GENERAL

.1.1 Inspection by the A/E and FOD Utilities: Material, equipment, design, and workmanship shall at all times be subject to the inspection of the A/E and FOD Utilities and, upon being notified in writing by the A/E, any material, equipment, or workmanship not meeting the specified requirements shall be replaced or reworked immediately without additional cost to the University.

Inspection by the A/E and/or FOD Utilities shall not relieve the Contractor from the responsibility for full compliance with the specified requirements.

- .1.2 University-Furnished Drawings: The Drawings supplied by the University including the Contract Drawings are not intended to be fabrication drawings. Dimensions for pipe fabrication shall be field checked prior to fabrication.
- .1.3 Do not interrupt utility services unless permitted in writing by the accountable University representative. Outages to existing utility systems must be planned and scheduled at least two weeks in advance. See outage procedure: [https://ap.osu.edu/sites/default/files/utility\\_outage\\_procedures.docx](https://ap.osu.edu/sites/default/files/utility_outage_procedures.docx)

.2 PREPARATION

- .2.1 Remove scale, slag, dirt, and debris for both inside and outside of piping and fittings before assembly.
- .2.2 Conformance: The Contractor shall be responsible for checking and conforming to size, location, and flange drilling of all piping, valves, flow nozzles, and material furnished by the University for this piping installation.
- .2.3 Measurement Verification by the Contractor: Before fabrication, the Contractor shall verify all measurements at the site and obtain all necessary additional information for completion of the Work, including the following:
  - .2.3.1 Actual location of weld nozzles, flanges, or other type of terminal connections and verification of weld nozzle ends and flange facings that are existing, to which the Contractor's Work must connect.
  - .2.3.2 Exact location of existing piping with supports and hangers in place
  - .2.3.3 Exact location of new and existing structures and equipment
  - .2.3.4 Interferences and difficulties that may exist
  - .2.3.5 The Contractor shall take such field measurements and allow for such makeup lengths or closures necessary for accurate alignment and assembly.

.3 INSTALLATIONS

- .3.1 General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leak-proof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 0.05 inches misalignment tolerance.
- .3.2 Piping Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location arrangement and restrictions of the piping systems. Location and arrangement of piping layout shall take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.
- .3.3 Piping Alignment:
  - .3.3.1 For piping systems between anchors that contain externally pressurized or slip-type (packed) expansion joints, use a laser to align the piping so that it is straight and that there will be no binding when the pipe thermally expands into the expansion joint. Use the laser alignment during fabrication of the piping system and when



- adjusting pipe support, guide, expansion joint, and anchor vertical elevations. Laser alignment equipment shall remain attached to the piping system until approved to be removed by the A/E after the A/E has witnessed the alignment.
- .3.3.2 Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.
  - .3.3.3 Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated on the Contract Drawings.
  - .3.3.4 Locate groups of pipes parallel to each other, spaced to permit applying full insulation, servicing of valves, and thermal expansion of piping systems.
- .3.4 Install drains at low points in mains, risers, and branch lines consisting of a tee, reducing tee, weld-o-let, or soc-o-let fitting, applicable 3/4-inch shut-off valve, 3/4-inch nipple, and cap for pipe sizes 6 inches and smaller; provide 2-inch shut off valve, nipple, and cap for pipe sizes 8 inches and larger. All components shall conform to the piping systems described in this Section and to Section 33 63 35 –VALVES. The location of the high point vents and low point drains shall be approved by the A/E.
- .3.5 Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical rooms or electronic equipment spaces and enclosures. In no instance shall piping be routed above electrical equipment.
- .3.6 Interferences: Do not run piping or conduits through ducts or equipment cabinets.
- .3.7 Shop Prefabrication:
- .3.7.1 Where shop prefabrication is not specified but is done as the Contractor's choice, any adjustments necessary due to inaccuracies in equipment setting and dimensions or location of existing obstructions shall be done at no additional cost. No shop fabrication sketches will be checked by the A/E, but Contractor shall submit drawings to the A/E for information.
  - .3.7.2 All shop fabrication shall be fabricated to dimensional tolerances in accordance with Pipe Fabrication Institute Standard ES-3. Accumulated tolerances between fixed points shall not exceed plus or minus 3/8 inch.
- .3.8 Connections Equipment and Piping Specialties:
- .3.8.1 Contractor shall erect and support piping in manner that shall not put undue strain on the equipment or piping specialty
  - .3.8.2 The procedure for connection of piping to equipment or piping specialty shall be as follows:
    - .3.8.2.1 After the equipment piping specialty has been set and grouted, the Contractor shall run the pipe from the equipment.
    - .3.8.2.2 Flat faced flanges and full face gaskets shall be used on piping connecting to equipment with flat faced flanges.

Raised faces of standard flanges may be machined off flat to accomplish this. Bolting for these joints shall be per ASME B31.1.

.3.8.2.3 Flanges shall be checked by the A/E to assure that no strain is placed on the equipment. If pipe is not in correct alignment, the Contractor shall remove piping and correct. The correction in alignment shall not be made while the pipe is connected to the equipment.

.3.8.3 After alignment is found correct by the A/E, the Contractor shall bolt up the flanges.

.3.8.4 When required by the A/E after the equipment has been in service, tested at operating temperatures, and with the lines and equipment still hot, the Contractor shall loosen flange connections to pumps, tanks, and equipment, and check for alignment, position, expansion, and strain applied to the equipment; make any adjustments necessary, and obtain approval of the A/E before reconnecting.

.3.8.5 Provide temporary strainers as directed per Section 33 63 25- PIPING SPECIALTIES.

.3.9 Thermal Cutting: When thermal cutting is required, the material shall be in accordance with ASME B31.1 welding preheat requirements. Thermal cut surfaces shall be ground to remove all slag, oxide, and surface irregularities to 1/16 inch. Austenitic stainless steel pipe shall be cut by mechanical means only.

.3.10 Welded Attachments:

.3.10.1 Welded attachments shall include lugs, brackets, and similar devices welded to pipe for hangers, supports, and guides. Weld procedures used to attach such devices shall be compatible with the base material. Preheating shall be in accordance with ASME B31.1 requirements for piping material.

.3.10.2 All areas where lugs or attachments are removed or repaired shall be tested hydrostatically to meet accepted standards stated in ASME B31.1. Any linear indications shall be removed and the area retested. The procedure shall be repeated until no indications are noted.

#### .4 FITTINGS AND SPECIALTIES

.4.1 Use fittings for all changes in direction and all branch connections. For piping greater than 2 inch NPS, if the change in direction is less than 5 degrees, a miter is acceptable and must be provided in accordance with ASME B31.1. No miters are acceptable for angles greater than 5 degrees. For changes in direction greater than 5 degrees, cut a forged fitting. For pipe sizes 2 inch NPS and smaller, changes in direction shall be done with standard 45 and 90 degree elbows – no miters or cut fittings acceptable.

- .4.2 Pipe Elbows: Provide pipe elbows where depicted on the Contract Drawings. Use long radius elbows except where specifically designated on the Contract Drawings.
  - .4.3 Branches: Wherever branch pipe is indicated, install type of fitting shown on Contract Drawings, i.e. forged branch connection fitting, regular "T" fitting, or reducing "T" fitting. If the type of fitting is not shown on the Contract Drawings or specified in the piping specifications, the Contractor may choose between the above mentioned fittings, within the limits of the following:
    - .4.3.1 Forged branch connection fittings may only be used if the smaller branch pipe is at least two standard nominal pipe sizes smaller than the larger main pipe.
    - .4.3.2 All fittings and procedures conform to the specific piping group specification as scheduled in this Section.
    - .4.3.3 The Contractor shall provide taps into existing mains that will remain energized at up to piping system design pressure where a hot tap is specifically indicated on the Contract Drawings. This procedure is also known as wet tapping. Hot or wet tapping shall be performed by experienced personnel with special hot tap fabrication equipment. All hot tapping shall be coordinated with the University. Hot tapping is only allowed where indicated on the Contract Drawings or by written approval from the University.
  - .4.4 Reducers: Unless explicitly stated on Contract Drawings, use forged fittings. Use concentric fittings except for steam systems, for reducers in horizontal in direction of flow, use eccentric flat on bottom to allow condensate to continue flowing in direction of steam travel.
  - .4.5 Install dielectric unions to connect piping materials of dissimilar metals in dry piping systems (gas, compressed air). Unions shall be rated for the design basis working pressure and temperature of the piping system per this specification.
  - .4.6 Refer to Section 33 63 25 - PIPING SPECIALTIES for specification of pipe specialties including steam traps, strainers, etc.
- .5 JOINTS
- .5.1 Threaded Joints:
    - .5.1.1 Thread pipe with tapered pipe threads in accordance with ANSI B1.20.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Immediately before erecting the piping, all threads on pipe and all fittings shall be thoroughly cleaned of cuttings, dirt, oil, or other foreign matter.
    - .5.1.2 Ordinary or special-type screwed joints shall be kept to a minimum to reduce any possibility of leakage. Continuous runs of piping shall be used, wherever possible. All screwed connections shall have full threads of true taper and shall be accurate to gauge. Only Teflon shall be used on threaded joints that have a design temperature less than 500°F. Pipe compound shall be used on threaded joints that

have a design temperature greater than 500°F. Care shall be taken to prevent obstruction of pipe or tubing when using Teflon tape.

- .5.1.3 When screwed connections are specified to be seal welded, the pipe shall be threaded so that not more than one thread remains outside the joint. The pipe to be welded shall be cleaned to bare metal and free of oil, scale, and dirt. The joint shall be made up hand-tight, without tape, and shall be welded with not less than two light beads with the weld cleaned between successive passes. The seal weld shall completely cover the thread with no undercut on the pipe. Plugs to be installed in seal weld fitting shall be installed using Teflon tape, after all welding is complete.

.5.2 Welded Joints:

.5.2.1 General:

- .5.2.1.1 Weld pipe joints only when ambient temperature is above 0°F where possible.
- .5.2.1.2 Bevel pipe ends at a 37.5 degree angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
- .5.2.1.3 Use pipe clamps or tack-weld joints with 1-inch long welds; 4 welds for pipe sizes to 10 inches, 8 welds for pipe sizes 12 inches to 20 inches.
- .5.2.1.4 Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.
- .5.2.1.5 Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.
- .5.2.1.6 If piping component ends are bored, such boring shall not result in the finished wall thickness after welding less than the minimum design thickness.
- .5.2.1.7 The inside diameters of piping components to be butt-welded shall be aligned as accurately as is practicable within existing commercial tolerances on diameters, wall thickness and out of roundness. Alignment shall be preserved during welding. The internal misalignment of the ends to be joined shall not exceed 0.05 inch.

.5.2.2 Welding Processes:

- .5.2.2.1 All welding on metal piping systems shall be done using qualified welding and qualified welders and welding operators in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.
- .5.2.2.2 All welding shall be done by a process that is compatible with the work being welded and the working conditions.

- Shielded metal-arc welding (SMAW) shall not be used on work less than 3/16 inch thick.
- .5.2.2.3 Where a specific welding process is called for in the piping group, it shall govern.
  - .5.2.2.4 All stainless work shall use 316L electrodes for the filler metal except 304L for the PED piping. All stainless steel work less than 3/16 inch thick shall be welded by the gas tungsten-arc (GTAW) process with the back side purged. Work thicker than 3/16 inch shall have a root pass by the GTAW Process with the back purged and the balance of the weld may be completed by SMAW Process or any other suitable process.
  - .5.2.2.5 The root pass for all steam piping shall be per the GTAW tungsten inert gas (TIG) method with E6010 and another hot pass with E6010. The E6010 can be substituted with ER-70S-2 or ER70S-3.
  - .5.2.2.6 Pulse welding in the form of MIG (Metal Inert Gas) is not allowed for welds of this project. No spray welding is allowed.
- .5.2.3 Welding Grooves:
- .5.2.3.1 The ends of steel pipe and fittings to be erected with butt welded joints shall be beveled to form welding grooves in accordance with ANSI B16.25, except where otherwise noted in these Specifications, or on the Contract Drawings.
  - .5.2.3.2 Welding grooves for butt welded joints in pipe of unequal wall thickness shall be beveled in accordance with ASME Code for Pressure Piping B31.1 - latest edition, latest revision and section that is applicable.
- .5.2.4 Backing Rings: Backing rings or consumable inserts shall not be used and are not allowed.
- .5.2.5 Cleaning of Welding: All slag or flux remaining on the bead of welding shall be completely removed before laying down the next successive bead and at the completion of the weld.
- .5.2.6 Preheating of Welded Joints: Pipe adjacent to joints before and during welding shall be preheated by any suitable method in accordance with the qualified welding procedure and in all cases shall be in accordance with ASME B31.1, Paragraph 131.
- .5.2.7 Weld Quality:
- .5.2.7.1 All welds shall have full penetration and complete fusion with a minimum of weld metal protruding on the inside of the pipe.
  - .5.2.7.2 The finished weld contour shall be uniform, with the toe or edge of the weld merging smoothly into the base material. Butt welds shall have a slight reinforcement build-up gradually from the toe or edge toward the center of the

weld. The limitation on butt weld reinforcement shall be in accordance with ASME B31.1, Table 127.4.2 and shall apply separately to both inside and outside surfaces of the joint. Fillet welds may be slightly concave on the furnished surface.

- .5.2.8 Identification of Welders: Refer to Quality Assurance paragraph of Part 1 of this Section.
- .5.3 Socket Welding Joints: Where socket welding valves or fittings are used, the pipe shall be spaced with a minimum of 1/16-inch clearance between the end of the pipe and the socket so that no stresses will be imparted to the weld due to "bottoming" of the pipe in the socket. The fit between the socket and the pipe shall conform to applicable standards for socket weld fittings and in no case shall the inside diameter of the socket exceed the outside diameter of the pipe by more than 0.075 inches.
- .5.4 Non-ferrous Pipe Joints:
  - .5.4.1 Brazed and Soldered Joints: For copper tube and fitting joints, braze joints in accordance with ASME B31.1.
  - .5.4.2 Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emery cloth, prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.
- .5.5 Flanged Joints:
  - .5.5.1 Joint and flange assembly personnel for the Contractor shall follow the most recent guidelines published for Pressure Boundary Bolted Flange Joint Assembly ASME PCC-1. The Contractor shall submit to the A/E a flange-assembly procedure that includes start-up re-torque procedures and engineering risk analysis as described in 10. d.
  - .5.5.2 Before assembly is started, the Contractor shall clean and examine flange and fastener contact surfaces. If applicable, remove all indications of the previous gasket installation from the gasket contact surfaces. Use approved solvents and/or soft-wire brushes, if required, for cleaning to prevent surface contamination and damage to existing surface finish. Avoid using carbon steel brushes on stainless steel flanges.
  - .5.5.3 Match flanges and provide proper alignment of all joint members within the piping system and at connections with valves and equipment where specified. Follow the Flange Joint Alignment Guidelines as specified in Appendix E of ASME PCC-1.
  - .5.5.4 Place a new gasket in position after determining the absence of unacceptable gasket sealing imperfections and flatness tolerance deviations, as well as joint alignment considerations.
  - .5.5.5 Protect gasket surfaces from inadvertent application of approved lubricants. Only apply approved lubricants to working surfaces with

the bolt/nut/washer. Lubricants shall be chemically compatible with the bolt/nut/washer materials. All bolts shall be well lubricated over the entire thread. Contractor shall use White Hi-Temp Anti-Seize by Loctite or approved equal bolt lubricant on steam system piping.

- .5.5.6 Once the flanges are aligned, install the gasket and install bolts and nuts so they are hand-tight with the marked ends of the bolts and nuts located on the same side of the joint and facing outward to facilitate inspections. Tighten the joint using either the torque increment rounds shown in ASME PCC-1 Table 2; and either the companion in ASME PCC-1 Table 4 or Table 4.1 cross-pattern tightening sequences when using a single tool as described in Section 11, or one of the alternative tightening procedures shown in Alternatives #1, #2, and #3 of Appendix F of the ASME PCC-1.
- .5.5.7 All bolts in flanged construction shall be uniformly tightened with proper tools only. Hammering and bumping are prohibited. Care shall be taken to secure uniform pressure on the gasket to avoid overstressing of the bolts, dishing of flanges, and compression of the gasket beyond limits.
- .5.5.8 All slip-on flanges are to be welded on front and back, no exceptions. Welding neck flanges shall be bored to match the attached pipe.
- .5.5.9 Contractor shall be sure to release any aligning devices used to align jointed assemblies.
- .5.5.10 Start-up re-torque (also referred to as hot torque) shall be performed to decrease the likelihood of leakage during operation. Start-up re-torque is performed on steam system piping, hot water piping, or when the temperature of the pipe contents are between 300°F and 450°F or within 24 hours of unit start-up if the joint temperature remains below 300°F. The start-up re-torque shall be performed in accordance with the following:
  - .5.5.10.1 The ambient-temperature assembly Target Torque value should be adjusted to account for any change in nut factor with temperature.
  - .5.5.10.2 Once the unit is brought online and the metal temperature is between 300°F and 450°F or within 24 hours of unit start-up if the joint temperature remains below 300°F, then contractor shall proceed in a cross pattern and retighten each bolt to the specified torque in ASME PCC-1. The use of multi-tool tightening on opposing bolts is acceptable, but a cross pattern should be used.
  - .5.5.10.3 Continue tightening in the cross pattern until the nuts no longer turn.
  - .5.5.10.4 An engineering and risk analysis of the proposed start-up re-torque operation shall be carried out by the installing Contractor to establish that the operation can be performed safely. The Contractor shall take into account

site conditions, staff qualifications & experience, approved submittal data, manufacturer installation requirements & recommendations, and other critical installation factors when completing their analysis. Submit analysis to the A/E.

.6 CLEANING, FLUSHING, INSPECTING

- .6.1 General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Inspect each run of each system for completion of joints, supports, and accessory items.
- .6.2 Flush out and clean and then treat and refill the chilled water piping systems with a cleaning contractor. Contractor shall provide a cleaning procedure and treatment program for review and approval by the Architect/Engineer and FOD Utilities. Before proceeding, inspect each run of each system for completion of joints, supports, and accessory items.
- .6.3 Provide steam blow for steam piping per Section 33 63 15 – STEAM BLOWING.
- .6.4 The PCR piping receives no steam blow or flushing.

.7 PIPING TESTS - HYDROSTATIC

- .7.1 All non-boiler external piping shall be hydrostatically tested in accordance with Paragraph 137 of the ASME B31.1 Power Piping Code.
- .7.2 General:
  - .7.2.1 Provide temporary equipment for testing, including pump and gauges. The gauge shall be accurate to within 3 PSIG and shall be calibrated within six months of the test as recorded on a sticker on the gauge. Test piping system before insulation is installed. Pressure testing shall be performed following the completion of post-weld heat treatment, nondestructive examinations, and all other fabrication, assembly, and erection activities required to provide the system or portions thereof subjected to the pressure test with pressure retaining capability. Remove control devices before testing. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time. The Contractor shall provide air vents at all high points in the system to purge air pockets while the system is filling.
  - .7.2.2 The Contractor shall test each section of pipe before it is insulated and buried. Provide temporary piping including welded caps prior to the termination into existing piping so that new piping can be hydrostatically tested without having cold water against an active hot valve. After successfully hydrostatic testing, remove the temporary piping and caps and provide new piping to tie into existing piping. It is recognized that the final connection pieces to existing piping will not be hydrostatically tested; however, flow (at normal operating pressure) shall be established through the final



connection pieces and fittings, with no visual evidence of weeping or leakage, prior to insulation and burial.

.7.2.3 Air or other gas testing is not acceptable.

.7.3 Test Pressure:

.7.3.1 Test all steam, condensate, and pumped condensate at 1-1/2 times the design pressure listed in the table in Section .3 PIPING, GASKET, INSULATION, AND SERVICE GROUP INDEX. For example, for HPR, the design pressure is 200 PSIG. Therefore, the test pressure shall be 300 PSIG.

.7.3.2 The test pressure shall be continuously maintained for a minimum time of 4 hours. During this 4-hour period, no pressure drop shall be measured. After the 4-hour period, if necessary, the pressure may then be reduced to design pressure and held for such time as may be necessary to continue to conduct the examinations for leakage. Examinations for leakage shall be made of all joints and connections. The piping system shall show no visual evidence of weeping or leaking. Hydrostatic testing shall be witnessed by the University or Engineer. After any leaks are found and corrected, the test shall be repeated.

.7.4 Test Blinds:

.7.4.1 If during the field testing of piping it becomes necessary to insert test blinds in any part of this piping, the Contractor shall provide test blinds and all work required including the flanges and welding of flanges.

.7.4.2 Test blinds shall be equipped with a long handle.

.7.4.3 The Contractor shall submit a written description of the location of test blinds before testing.

.7.4.4 The Contractor shall remove all test blinds after testing.

.7.5 Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

.7.6 Records:

.7.6.1 It is the responsibility of the Contractor to keep accurate, updated records of all hydrostatic testing. The Contractor shall submit a final log of all hydrostatic testing for the Owner's records.

.7.6.2 The Contractor shall maintain a constantly updated list of the following for all hydrostatic tests:

.7.6.2.1 Date and time of test

.7.6.2.2 Hydrostatic test pressure

.7.6.2.3 Piping system tested

.7.6.2.4 Extent of piping system tested so that it can be clearly identified up to what point a piping system has been tested

.7.6.2.5 Test results. All failures shall be indicated with the cause explicitly stated.

.7.6.2.6 Signed witnesses of each test which shall be one employee of the Contractor and by the Engineer

.8 PIPING TESTS - VISUAL EXAMINATION

.8.1 General: Visually examine all pipe welds per ASME B31.1. As described below, visual examination of welds shall be performed by the Contractor. This type of testing is required by the code and shall not be paid for by the A/E.

.8.2 Acceptance Standards:

.8.2.1 The acceptance standards for visual examination shall be as defined in ASME B31.1, Paragraph 136.4.2.A, and are repeated here for convenience. The following indications are unacceptable:

- Cracks-external surface
- Undercut on surface which is greater than 1/32-inch deep
- Weld reinforcement greater than that specified in Table 127.4.2. of ASME B31.1
- Lack of fusion on surface
- Incomplete penetration (applies only when inside surface is readily accessible)
- Any other linear indications greater than 3/16 inch long
- Surface porosity with rounded indications having dimensions greater than 3/16 inch or four or more rounded indications separated by 1/16 inch or less edge to edge in any direction. Rounded indications are indications which are circular or elliptical with their length less than three times their width

.8.2.2 In addition, acceptance will also be based on the proper lay-out, materials, and methods, as specified.

.8.3 Failed Welds:

.8.3.1 All welds not passing visual examination shall be repaired or replaced at no expense to the University.

.8.3.2 Visual defects found shall require additional VT as recommended by inspector.

.8.3.3 Do not begin to repair or replace the weld until the weld report has been submitted to the A/E and the A/E gives approval for repairing the weld with the method that the Contractor proposes. Repair shall be performed using the qualified welding procedures applicable to the original weld.

.8.4 Reporting:

.8.4.1 Reports for visual examinations of welds shall be required for all piping larger than 3 inch NPS except for vent and drain services. Reports performed for visual examinations by the Contractor are not required to be submitted, but shall be kept available for review at any time by the University or A/E.

- .8.4.2 Each weld report shall include the following:
  - .8.4.2.1 Date of weld examination
  - .8.4.2.2 Type of examination
  - .8.4.2.3 Examiner's name
  - .8.4.2.4 Welders' names including all persons who worked on the weld and their work involved
  - .8.4.2.5 Piping system
  - .8.4.2.6 Weld location
  - .8.4.2.7 Weld procedure and materials
  - .8.4.2.8 Materials and dimensions of items that were welded
  - .8.4.2.9 Visual examination results
  
- .8.5 Examiners' Qualifications:
  - .8.5.1 All persons performing visual examinations and evaluating examinations shall be certified according to AWS QC1 or those requirements stated explicitly in ASME B31.1. It is not intended to have a third party inspector perform this service.
  - .8.5.2 Credentials and certification of all examiners must be submitted and approved prior to an examiner performing the initial examination.
  
- .8.6 Visual Examination Requirements:
  - .8.6.1 Welds designated for visual examination shall be examined after the weld is completed for cracks, contour and finish, bead reinforcement, undercutting, overlap, size of fillet welds, finished weld appearance, weld size, weld length, dimensional accuracy of weldment, and monitor post weld heat treatment.
  - .8.6.2 Records of visual examinations must be kept as described in this Section.
  - .8.6.3 Shop fabricated welds may be examined in the shop prior to arrival at the project site provided all other conditions of this Section are satisfied.
  
- .8.7 Examiner's Scope:
  - .8.7.1 Visual examinations to be performed by the Contractor may be performed and interpreted by an employee or employees of the Contractor, provided that each individual is certified as specified. As an option, the Contractor may obtain the services of an independent testing agency to perform these examinations.
  - .8.7.2 If the Contractor elects to utilize the services of an independent testing agency to perform any visual examinations, the following applies:
    - .8.7.2.1 The qualifications for the personnel of the independent testing agency performing the examinations shall be submitted.
    - .8.7.2.2 The Contractor shall provide all required access and lighting for the independent testing agency.

.8.7.2.3 The Contractor shall be responsible for all of the independent testing agencies activities, including handling submittals, performing evaluations at the required times, etc.

.8.7.3 A welder who has performed any work with regard to a specific weld shall not perform the visual examination of the same weld.

.9 PIPING TESTS – MAGNETIC PARTICLE (MT)

.9.1 General: The A/E will direct an independent testing agency to examine pipe welds using the magnetic particle method as indicated in the “Nondestructive Testing Requirements Index”, located in this Section. Where MT is designated, butt welds, socket welds, and welded branch connections for sizes NPS 2 and less will be examined per the requirements specified herein on the root and cap passes. Magnetic Particle testing will be paid for by the A/E except for retests for failed welds which shall be paid for by the Contractor.

.9.2 Acceptance Standards: Will be in accordance with Paragraph 136.4.3 of ASME B31.1. The A/E may, at his sole discretion, elect to waive some of the acceptance standards on a case-by-case basis.

.9.3 Procedure:

.9.3.1 Magnetic particle examination will be performed in accordance with Article 7 of Section V of the ASME Boiler and Pressure Vessel Code.

.9.3.2 The procedure will be as described in Paragraph T-721 of Article 7 of Section V of the ASME Boiler and Pressure Vessel Code.

.9.4 Reporting:

.9.4.1 The report of each magnetic particle examination will be submitted to the A/E and the University within 2 working days of the examination by the ITA.

.9.4.2 In addition to the requirements of Paragraph T-761 of Article 7 of Section V of the ASME Boiler and Pressure Vessel Code, each weld report will include the following:

.9.4.2.1 Date of weld examination

.9.4.2.2 Type of examination

.9.4.2.3 Examiner's name

.9.4.2.4 Welders' names including all persons who worked on the weld and their work involved

.9.4.2.5 Pipe system

.9.4.2.6 Weld location

.9.4.2.7 Weld procedure and materials

.9.4.2.8 Materials and dimensions of items that were welded

.9.4.2.9 Magnetic particle examination results

.9.5 Examiner's Qualifications: All persons performing and evaluating magnetic particle examinations will be certified for NDT Level II MT as recognized by the ANST. A Nationally Certified Level III MT technician per ASNT shall be on staff

at the testing laboratory. A Corporate Level III MT without National Certification is not acceptable.

.9.6 Magnetic Particle Examination Requirements:

.9.6.1 The A/E will be responsible for obtaining and paying for the services of the independent testing agency, except for retesting of failed welds which shall be paid by the Contractor. The Contractor is responsible for providing access to the welds for the Independent Testing Agency.

.9.6.2 When a limited number of welds are specified (not 100%), the welds to be examined shall be random. The A/E will designate the specific welds that are to be randomly tested as the job is in progress.

.9.6.3 It is suggested to the Contractor that the Contractor should notify the A/E when welds that require scaffolding are complete so that the Contractor will not have to re-build scaffolding to gain access to the welds.

.9.6.4 Shop fabricated welds will be examined in the field.

.9.7 Failed Welds:

.9.7.1 All welds not passing magnetic particle examination shall be repaired or replaced at no expense to the University or A/E.

.9.7.2 Do not begin to repair or replace the failed weld until the weld report has been submitted to the A/E and University and the A/E gives approval for repairing the weld with the method that the Contractor proposes. Repair shall be performed using the qualified welding procedures applicable to the original weld.

.9.7.3 All failed welds discovered by magnetic particle examination will be re-examined by magnetic particle examination after the weld is repaired or replaced at no additional cost to the University or A/E with the report being submitted to the A/E and the University within 2 working days of the examination which shall reference the repair of the particular weld.

.10 PIPING TESTS - ULTRASONIC EXAMINATION (UT)

.10.1 General: The A/E will direct an independent testing agency to ultrasonically examine pipe welds as indicated in the "Nondestructive Testing Requirements Index", located in this Section. Where Ultrasonic testing (UT) is designated, it will be performed on piping sizes larger than 2 inch NPS. UT will be paid for by the A/E except for retests for failed welds which shall be paid for by the Contractor.

.10.2 Acceptance Standards: Shall be in accordance with Paragraph 136.4.6 of ASME B31.1. The A/E and University may, at their sole discretion, elect to waive some of the acceptance standards on a case by case basis.

.10.3 Procedure:

.10.3.1 Ultrasonic examination will be performed in accordance with Article 5 of Section V of the ASME Boiler and Pressure Vessel Code.

.10.3.2 The procedure will be as described in Paragraph T-593 of Article 5 of Section V of the ASME Boiler and Pressure Vessel Code.

- .10.4 Reporting:
  - .10.4.1 The report of each ultrasonic examination will be submitted to the A/E and University within 2 working days of the examination.
  - .10.4.2 In addition to the requirements of Paragraph T-593 of Article 5 of Section V of the ASME Boiler and Pressure Vessel Code, each weld report will include the following:
    - .10.4.2.1 Date of weld examination
    - .10.4.2.2 Type of examination
    - .10.4.2.3 Examiner's name
    - .10.4.2.4 Welders' names including all persons who worked on the weld and their work involved
    - .10.4.2.5 Pipe system
    - .10.4.2.6 Weld location
    - .10.4.2.7 Weld procedure and materials
    - .10.4.2.8 Materials and dimensions of items that were welded
    - .10.4.2.9 Ultrasonic examination results
- .10.5 Examiner's Qualifications: All persons performing and evaluating ultrasonic examinations will be certified for NDT Level II as recognized by the American Society for Nondestructive Testing (ANST).
- .10.6 Ultrasonic Examination Requirements:
  - .10.6.1 The A/E shall be responsible for obtaining and paying for the services of the independent testing agency, except for retesting of failed welds which shall be paid for by the Contractor. The Contractor is responsible for providing access to the welds for the Independent Testing Agency.
  - .10.6.2 When a limited number of welds are specified (not 100%), the welds to be examined shall be random. The A/E will designate the specific welds that are to be randomly tested as the job is in progress.
  - .10.6.3 It is suggested to the Contractor that the Contractor should notify the A/E when welds that require scaffolding are complete so that the Contractor will not have to re-build scaffolding to gain access to the welds.
  - .10.6.4 Shop fabricated welds will be examined in the field.
- .10.7 Failed Welds:
  - .10.7.1 All welds not passing ultrasonic examination shall be repaired or replaced at no expense to the University or A/E.
  - .10.7.2 Do not begin to repair or replace the failed weld until the weld report has been submitted to the A/E and the A/E gives approval for repairing the weld with the method that the Contractor proposes.
  - .10.7.3 All failed welds discovered by ultrasonic examination shall be re-examined by ultrasonic examination after the weld is repaired or replaced at no additional cost to the University with the report being submitted to the A/E and the University within 2 working days

of the examination which shall reference the repair of the particular weld.

- .11 NONDESTRUCTIVE TESTING REQUIREMENTS INDEX: THE NONDESTRUCTIVE TESTING REQUIREMENTS INDEX IS LISTED BELOW: “NR” MEANS “NOT REQUIRED.”

SERVICE	LINE DESCRIPTION & DESIGN CONDITIONS	VISUAL	MT	UT	SERVICE GROUP ON DWGS
EQUIPMENT DRAIN, PUMPED	50 PSIG at 212°F Max., from Sump Pump Discharge in Trenches	NR	NR	NR	PED
CONDENSATE, HIGH PRESSURE	200 PSIG at 600°F Max., from HPS to PC System	100%	NR	NR	HPR
CONDENSATE, PUMPED	200 PSIG at 388°F Max., Returned Condensate from Campus and Manhole Pumps to Plant	100%	NR	NR	PCR
STEAM, HIGH PRESSURE	200 PSIG at 600°F Max., HPS Campus Distribution	100%	100%	100%	HPS
CHILLED WATER SUPPLY AND RETURN	150 PSIG at 140°F Max., Chilled water from/to chiller plants and buildings	100%	100%	100%	CWS & CWR

- .12 OPERATING TEST AND FINAL INSPECTION

- .12.1 New utility piping systems shall not be placed in service if these Standards are not met or if the design or A/E approved equipment or installation fails these Standards or inspections by the authority having jurisdiction.
- .12.2 A structured inspection and review process shall be followed per the Utility Service Connection and Inspection Standards:

[https://fod.osu.edu/sites/default/files/utility\\_service.pdf](https://fod.osu.edu/sites/default/files/utility_service.pdf)

Checklists are available from FOD Utilities. Pre in-service checks include cleaning, pressure testing, insulation, painting, and identification.

- .12.3 Upon completion of pre-service tests, the work shall be tested by an operating test performed by the University under normal service conditions.
- .12.4 Upon completion of each operating test, the Contractor shall correct loose or faulty hangers and shall provide required devices to eliminate sway or vibration of piping.

- .13 INSULATION, PAINTING, AND IDENTIFICATION

- .13.1 Insulate all piping as indicated in Section 33 63 55 - PIPING INSULATION.
  - .13.2 Piping identifications shall be in accordance with Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.
  - .13.3 Paint piping systems in accordance with Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.
  - .13.4 Internal Cleaning of Piping: Refer to Part 3-Execution; Section .6 CLEANING, FLUSHING, INSPECTING.
- 33 63 10.2 PIPING GROUP 2 – CARBON STEEL - CHILLED WATER SUPPLY AND RETURN PIPE – CWS and CWR
- .1 DESIGN BASIS
    - .1.1 Working pressure, 100 psig at 140°F.
    - .1.2 Piping Group 2 – Carbon Steel.
  - .2 PIPE
    - .2.1 All pipes shall be ASTM A 106 or ASTM A 53, Grade B, Type S, seamless Pipe wall thickness shall be as follows:  
1" through 24"                      Schedule 40
  - .3 JOINTS
    - .3.1 Joints 2 inches and smaller shall be screwed.
    - .3.2 Joints 2-1/2 inches and larger shall be butt welded.
    - .3.3 All sizes shall be flanged where shown on the Contract Drawings or where required to connect to flanged valves, fittings, or equipment.
  - .4 STRESS RELIEVING
    - .4.1 Stress relieving and pre and/or post weld heat treatment is not required.
  - .5 FABRICATION AND ERECTION
    - .5.1 Fabrication and erection shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.
  - .6 TESTING
    - .6.1 Testing shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.
  - .7 FLANGES
    - .7.1 Flanges 24 inches and smaller shall be Class 150 welding neck type in accordance with ANSI B16.5 and raised faced as required to match the mating flange. Material shall conform to ASTM A 105. Welding neck flanges shall be bored to match the same ID as the attached pipe.
  - .8 FITTINGS
    - .8.1 Fittings 2 inches and smaller shall be 150 pound screwed banded malleable iron in accordance with ANSI B16.3. Material shall conform to ASTM A 197.



DIVISION 33 – UTILITIES

---

.8.2 Fittings 2-1/2 inches and larger shall be steel, butt welded type in accordance with ANSI B16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 234, Grade WPB.

.9 BOLTING MATERIALS

.9.1 Bolting materials shall be mild steel, hexagonal head bolts with heavy hexagonal nuts conforming to ASTM A 307, Grade B.

.10 UNIONS

.10.1 Unions 2 inches and smaller shall be 150 pound malleable iron, brass seat, nut type. Material shall conform to ASTM A 197.

.10.2 Unions 2-1/2 inches and larger shall be made with flanges.

33 63 10.20 PIPING GROUP 3 – CARBON STEEL - HIGH PRESSURE STEAM PIPE - HPS

.1 DESIGN BASIS

.1.1 Design minimum working pressure and temperature: 200 psig and 600°F.

.1.2 Piping Group 3 – Carbon Steel Pipe.

.2 PIPE

.2.1 All pipe through 16 inches shall be seamless carbon steel conforming to ASTM A53 Grade B Type S or ASTM A 106 Grade B Type S. Pipe wall thickness shall be as follows:

1 through 16 inches                      Schedule 40 (Hard Schedule 40, not "STD")

.2.2 All threaded pipe nipples shall be Schedule "XSTG" conforming to ASTM A 106, Grade B.

.3 JOINTS

.3.1 Joints 2 inches and smaller shall be socket welded.

.3.2 Joints 2-1/2 inches and larger shall be butt welded.

.3.3 All sizes shall be flanged where shown on the Contract Drawings or where required to connect to flanged valves, fittings, or equipment.

.4 STRESS RELIEVING

.4.1 Stress relieving and pre and/or post weld heat treatment is not required.

.5 FABRICATION AND ERECTION

.5.1 Fabrication and erection shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.6 TESTING

.6.1 Testing shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.7 FLANGES





.2.3 Any pipe delivered for incorporated in the work which shows any signs of improper welding techniques, signs of rust, or other forms of corrosion will be rejected.

.3 JOINTS

.3.1 Joints 2 inches and smaller shall be socket welded.

.3.2 Joints 2-1/2 inches and larger shall be butt welded.

.3.3 All sizes shall be flanged where shown on the Contract Drawings or where required to connect to flanged valves, fittings, or equipment.

.4 STRESS RELIEVING

.4.1 Stress relieving and pre and/or post weld heat treatment is not required.

.5 FABRICATION AND ERECTION

.5.1 Fabrication and erection shall be in accordance with Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.

.6 TESTING

.6.1 Testing shall be in accordance with Section 33 63 10 –COMMON WORK RESULTS FOR PIPING.

.7 FLANGES

.7.1 Flanged joints shall be weld neck joints. Material shall conform to ASTM Specification A 182, F316L. Flanges shall be ANSI Class 300, ANSI B16.5.

.8 FITTINGS

.8.1. 2 Inches and Smaller: Fittings shall be socket weld type, Class 3000, in accordance with ANSI B16.11 and of the same thickness as the attached pipe. Material shall conform to ASTM A182, F316L.

.8.2. 2-1/2 Inches and Larger: Fittings shall be stainless steel butt-welded type in accordance with ANSI B16.11 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 403, Grade WP 316L.

.9 BOLTING MATERIALS

.9.1 Bolting shall consist of a bolt head which requires one nut on the opposite side on the threaded end in accordance with ANSI B1.1, Class 2A. Bolting materials shall be ASTM A193, Grade B7. Nuts shall be heavy series, hexagon, carbon steel, ASTM A194 Grade 2H, dimensional requirements per ANSI B18.2.2.

.10 UNIONS

.10.1 Unions 2 inches and smaller shall be 3,000 pound forged stainless steel socket weld with stainless steel seats.

.10.2 Unions 2-1/2 inches and larger shall be made with flanges.

33 63 13.94 UNDERGROUND CONDENSATE DISTRIBUTION PIPING

PART 1 - GENERAL

.1 RELATED DOCUMENTS

- .1.1 Contract Drawings and General Provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections apply to this Section.

.2 DESCRIPTION OF WORK

- .2.1 All underground condensate lines, as indicated on contract drawings, shall be Class A testable, drainable, and dryable. The system supplier shall have fabricated systems of the composition herein for at least three years. All straight sections, fittings, anchors, and other accessories shall be factory prefabricated to job dimensions and designed to minimize the number of field welds. Each system layout shall be computer analyzed by the piping system manufacturer to determine the stresses on the carrier pipe and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ASME B31.1, latest edition. Factory trained field technical assistance shall be provided for the critical periods of installation, i.e., unloading, field joint instruction, and testing. The preapproved conduit system shall include all piping and components to a point twelve inches inside the building, or manhole wall.

- .2.2 The system suppliers' representative shall be responsible for directing the installation and testing of the conduit system. It shall be certified in writing by the supplier that the representative is technically qualified and experienced in the installation of the systems. The supplier's representative shall be present during the following work phases:

- Inspection and unloading
- Inspection of trench prior to laying of conduit
- Inspection of expansion loops
- Inspection of joining of system
- Air test (conduit)
- Repair of any patchwork
- Back filling of conduit sections

- .2.3 The contractor shall not perform any of the above stated work in the absence of the system supplier's representative.

- .2.4 The contractor performing the work shall be responsible for the installation of the preapproved system and all other components of the underground condensate conduit systems, including the manholes and the piping equipment in the manholes and buildings. This responsibility shall include all site work and purchase of the preapproved system from the system supplier.

.3 SUBMITTALS

- .3.1 Refer to Division 1 and Common Work Results for Mechanical for administrative and procedural requirements for submittals.
- .3.2 Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for the type of manufactured piping specialty.

- .3.3 Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support. A complete engineering stress analysis indicating all anchors, fittings, dimensions in three axes, thermal movement calculations, maximum anticipated stresses and maximum allowable stresses must be submitted.
- .3.4 Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.
- .3.5 Quality Control Submittals:
  - .3.5.1 Submit welders' certificates specified in Quality Assurance below.
  - .3.5.2 Welding procedures
- .3.6 Excavation Support and Protection:
  - .3.6.1 Prior to starting work, submit for review and approval, calculations, and shop drawings showing each proposed method of supporting adjacent earth and structures; i.e. retention system and other methods of bracing. Include the following:
    - .3.6.1.1 Lists of material to be used, including design mixes
    - .3.6.1.2 Sequence of operations
    - .3.6.1.3 Detailed sections clearly illustrating the scope of work
    - .3.6.1.4 Relationship of piles, lagging, walls, and bracing to new and existing structures
    - .3.6.1.5 Location of utilities and details of support when required
    - .3.6.1.6 Procedures and details of testing
  - .3.6.2 Shop drawings and calculations: Prepared by qualified Licensed Professional Engineers registered in the State of Ohio and bearing their seals and signatures.
  - .3.6.3 Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of complete projects with project names and addresses, names and addresses of architects and the owners, and other information specified.
- .3.7 Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by excavation support and protection systems.
- .4 QUALITY ASSURANCE
  - .4.1 Welder's Qualifications: All welders shall be certified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing qualifications.
  - .4.2 Welding procedures and testing shall comply with ASME B31.1-Code Power Piping Code and The American Welding Society, Welding Handbook.
  - .4.3 Excavation Support and Protection:

- .4.3.1 Comply with the Publications of the following agencies to the extent referenced and applicable:
    - ASTM - American Society for Testing and Materials.
    - AISC - American Institute of Steel Construction.
    - OSHA - Occupational Safety and Health Act.
  - .4.3.2 Installer Qualifications: Engage an experienced installer to assume engineering responsibility and perform work of this Section who has specialized in installing excavation support and protection systems similar to those required for this Project and with a record of successful in-service performance.
  - .4.3.3 Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the State of Ohio and who is experienced in providing engineering services for designing excavation support and protection systems that are similar to those indicated for this Project in material, design, and extent.
  - .4.3.4 Engineering Responsibility: Engage a qualified professional engineer to prepare or supervise the preparation of data for the excavation support and protection system including drawings and comprehensive engineering analysis that shows the system's compliance with specified requirements.
  - .4.3.5 Do not install excavation support and protection system until successfully reviewed by AE.
- .5 JOB CONDITIONS
- .5.1 Before starting work, check and verify governing dimensions and elevations. Survey condition of adjoining surfaces. Photograph existing conditions to record any prior settlement or cracking of structures, pavements, and other deficiencies. Prepare a list of existing damages, verified by dated photographs and signed by the University.
  - .5.2 Survey adjacent structures and improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations. Locate datum level used to establish benchmark elevations.
  - .5.3 Contractor shall schedule a "Direct Buried Underground Condensate Piping Systems" pre-construction meeting with the Project Manager and AE to review installation requirements. The meeting shall take place after all submittals have been approved, but prior to any utility installation/construction.
- .6 EXISTING UTILITIES
- .6.1 The contract drawings indicate the general location of underground utilities. All utility locations and elevations in the vicinity of work shall be verified by the contractor prior to the start of project work. Test pits shall be conducted in areas where conflicts may occur prior to any excavation, heavy equipment loading, drilling and setting the H-piles is performed so as to avoid damaging or interfering with these existing utilities.

- .6.2 Do not interrupt utility services unless permitted in writing by the accountable University representative. Outages to existing utility systems must be planned and scheduled at least two weeks in advance.

.7 DELIVERY, STORAGE, AND HANDLING

- .7.1 Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, and clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
- .7.2 Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.
- .7.3 Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping.

PART 2 - PRODUCTS

.1 PIPE MATERIALS AND FITTINGS

.1.1 Systems Designs:

- .1.1.1 Pumped Condensate: Maximum operating conditions are 200 PSIG at 388°F. Design conditions for the system shall be 200 PSIG at 388°F.
- .1.2 Service Pipe: Condensate piping shall be Type TP316L, schedule 40, seamless stainless steel conforming to ASTM A312. All joints shall be butt-welded for sizes 2-1/2 inches or greater. Where possible, straight sections shall be supplied in 40 foot random lengths with 6 inches of piping exposed at each end for field joint fabrication.
- .1.3 Fittings: Fittings 2-1/2 inches and larger shall be steel butt-welding type in accordance with ANSI B 16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A403, Grade WP 316L.
- .1.4 Sub-Assemblies: Gland seals, end seals, and direct buried anchors shall be designed and factory prefabricated to prevent the ingress of moisture into the system. All sub-assemblies shall be designed to allow for complete draining and drying of the conduit system.
- .1.5 Insulation: Insulation shall be cellular glass for the service pipe and polyurethane for the outer conduit. Insulation of the service pipe at each field welded joint shall be held in place by stainless steel bands with the minimum of two bands and the maximum spacing of 12 inches. The insulation shall have passed the most recent boiling test and other requirements specified in the Federal Agency Guidelines. All condensate piping shall have a minimum insulation thickness of 3 inches.
- .1.6 Outer Conduit: The steel conduit casing shall be airtight, pressure testable, smooth wall welded steel conduit.
- .1.7 Outer Conduit Insulation and Jacket: Conduit insulation shall be 1 inch thick factory applied foam, meeting ASTM C591. The outer jacket shall be either:
  - .1.7.1 Fiberglass (FRP), which filament wound directly onto the urethane foam insulation, with minimum wall thickness of 0.125 inches.



Fiberglass field enclosures matching the thickness of the outer jacket shall be used to complete the installation closures. No shrink wrap type will be allowed for closure joints.

- .1.7.2 High Density Polyethylene (HDPE) jacket with minimum wall thickness of 0.125 inches. A pressure testable electric-fusion process or heat shrinkable process (recommended by the manufacturer) HDPE field joint closures equal to or greater than in thickness to the outer jacket shall be used to complete the installation closure. No shrink wrap type will be allowed for closure joints.
  
- .1.8 Pipe Supports: All pipes within the inner casing shall be supported continuously around service pipe at not more than 10 foot intervals. These supports shall be designed to allow for continuous airflow and drainage of the conduit in place. The straight supports shall be designed to occupy not more than 10% of the annular air space. Supports shall be of the type where insulation thermally isolates the carrier pipe from the outer conduit. Supports which directly contact both the carrier pipe and the outer casing shall not be allowed. The surface of the insulation shall be protected at the support by a sleeve not less than 12 inches long, fitted with traverse and where required, rotational arresters.
- .1.9 Anchors: Prefabricated steel plate anchors shall be factory furnished and installed where shown on plans. A concrete block shall be cast over the plate and conduit and shall be large enough for firm anchorage into undisturbed trench sidewalls and/or bottom. The concrete block is to be at least 30 inches in length and extend a minimum of 9 inches beyond the top and bottom of anchor plate.
- .1.10 Expansion Loops, Ells, and Tees: Expansion utilizing prefabricated ELLS without loops is only allowed as defined on the drawings. Expansion loops shall be of proper design in accordance with stress limits indicated by the code for pressure piping ASME B31.1. Loop piping shall be installed in conduit suitable sized to handle indicted pipe movement.
- .1.11 Backfill: A 6 inch layer of sand or pea gravel shall be placed and tamped in the trench to provide uniform bedding for the conduit. The entire trench shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 inches above the top of the insulated piping system. Bedding and backfill materials shall be as recommended by the manufacturer.
- .1.12 Manufacturers: Insul-Tek "Dual-Con", Thermacor Process Inc. "Duo-Therm 505", Perma-Pipe "Multi-Therm 500", or approved equal.
  
- .2 SOIL MATERIALS
  - .2.1 Refer to Section 31 00 00 – EARTHWORK.
  
- .3 BURIED UTILITY WARNING AND IDENTIFICATION TAPE:
  - .3.1 Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried

pipng. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 6 inches minimum width, color; yellow, with warning and identification imprinted in big black letters continuously and repeatedly over entire tape length. Warning and identification shall read "CAUTION BURIED STEAM SYSTEM DISTRIBUTION PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

PART 3 - EXECUTION

.1 EXCAVATION FOR UTILITY TRENCHES

- .1.1 Excavate trenches to indicated slopes, lines, depths, and invert elevations.
- .1.2 Excavate trenches to uniform widths to provide a working clearance on each side of pipelines. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.
- .1.3 Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove stones and sharp objects to avoid point loading.
- .1.4 Where encountering rock or another unyielding bearing surface, carry trench excavation 6 inches below invert elevation to receive sub-base course material.

.2 INSTALLATION

- .2.1 The installing contractor shall handle the system in accordance with the directions furnished by the manufacturer and as approved by the engineer.

.3 OUTER CONDUIT JACKET AIR TEST

- .3.1 In cases that a HDPE outer jacket is used, the Contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc. and complete the test to the satisfaction of the engineer. The field closure joint HDPE outer jacket shall be air tested at 8 PSIG. Testing shall occur in the field after fabrication is complete or as specified in the contract documents. The test pressure shall be held for not less than one hour. The test results shall be provided to the University.

.4 OUTER CONDUIT AIR TEST

- .4.1 The Contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc. and complete the test to the satisfaction of the engineer. The casing shall be air tested at 8 PSIG. Testing shall occur in the field after fabrication is complete or as specified in the contract documents. The test pressure shall be held for not less than one hour.

.5 SERVICE PIPE FIELD WELD INSPECTION

- .5.1 Ultrasonically test one hundred percent (100%) of the full penetration field welds in the steam systems. Testing shall be performed by a qualified independent testing contractor. All fillet and socket welds shall be visual and dye penetrant examined on the completed weld by an individual qualified to perform the examinations.
  - .5.2 Provide documentation of each inspection of accepted or rejected welds. Provide report results within three working days for satisfactory results and one working day for unsatisfactory tests.
  - .5.3 Remove weld defects by grinding or chipping and repair or replace weld joints in accordance with approved procedures. Retest all repaired joints.
  - .5.4 The Supplier's representative and the University's representative or Engineer shall be present during testing.
- .6 FIELD QUALITY CONTROL
- .6.1 Piping Tests: Fill pipeline 24 hours prior to testing and apply test pressure to stabilize system. Use only potable water.
  - .6.2 Do not proceed until test results on subgrade, fill and backfill layers for previously completed work verify compliance with requirements. Coordinate with the Independent Soil Testing Agency (hired by contractor, but approved by the University) to perform all tests.
    - .6.2.1 The Independent Soil Testing Agency will perform field in-place density tests in accordance to ASTM D1556 (sand cone method), ASTM D2167 (rubber balloon method), or ASTM D2937 (drive cylinder method), as applicable.
      - .6.2.1.1 In-place density field tests may also be performed by the nuclear method according to ASTM D2922, provided that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM D1556. With each density calibration check, check the calibration curves furnished with the moisture gauges according to ASTM D3017.
      - .6.2.1.2 When in-place density field tests are performed using nuclear methods, make calibration checks of both density and moisture gauges at beginning of work, on each different type of material encountered, and at intervals as directed by the University.
    - .6.2.2 Trench Backfill: In each compacted initial and final backfill layer, perform at least one field in-place density test for each 150 feet or less of trench, but no fewer than two tests per layer.
  - .6.3 When subgrades, fills, or backfills are below specified density, scarify and moisten or aerate, or remove and replace soil to the depth required, re-compact and retest until required density is obtained. Contractor shall pay for all retesting by the Independent Soil Testing Agency and corrective actions.
- .7 VERIFICATION OF FINAL ELEVATIONS

.7.1 Prior to covering the top of the casing with backfill material, but after all temporary supports have been removed and initial backfilling of the conduit systems have been accomplished, the contractor shall measure and record the elevation of the top of the casings in the trench. This measurement shall be checked against the contract drawings. These measurements shall confirm that the conduit system have been installed to the elevations shown on the contract drawings. These measurements shall be certified correct by the Contractor and provided to the University for review prior to covering the casing with backfill material. The preapproved conduit system shall be installed, inspected, and tested in accordance with the contract drawings and specifications, the system supplier's Approved Brochure and any directions given by the system supplier's representative. All work pertaining to the preapproved system shall be performed in the presence of the system supplier's representative.

.8 UTILITY TRENCH BACKFILL

- .8.1 Place and compact base course material on rock and other unyielding bearing surfaces and to fill unauthorized excavations.
- .8.2 Concrete backfill trenches that extend below or pass under footings and that are excavated within 18 inches of footings. Place concrete to elevation of bottom of footings.
- .8.3 Place and compact initial backfill of satisfactory soil material or sub-base material, free of particles larger than 1 inch, to a height of 6 inches over the utility pipe or conduit.
  - .8.3.1 Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
  - .8.3.2 Place backfill and fill materials in layers not more than 6" in loose depth for material compacted by heavy power-operated compaction equipment, and not more than 4" in loose depth for material compacted by hand-operated tampers.
  - .8.3.3 Compact soil to 95% of its maximum dry density in accordance with ASTM D698.
- .8.4 Coordinate backfilling with utilities testing.
- .8.5 Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.
- .8.6 Use one bag mix to completely backfill all voids of less than one (1) foot between new and existing utilities.
- .8.7 Place and compact final backfill of satisfactory soil material to final subgrade.
- .8.8 Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

33 63 15 STEAM BLOWING

PART 1 - GENERAL

.1 RELATED DOCUMENTS

- .1.1 Contract Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to work of this Section.
- .2 DESCRIPTION OF WORK
  - .2.1 This Section specifies the requirements for the steam blowing of steam piping.
- .3 SUBMITTALS
  - .3.1 Shop Drawings and Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
    - .3.1.1 Detailed written description of the steam blow procedures. Include the following:
      - .3.1.1.1 An estimation of how much piping is going to be temporarily installed and what size
      - .3.1.1.2 Estimated time for each steam blow and how many total blows estimated to be required
      - .3.1.1.3 Step by step steam blow procedure; Indicate all safety measures and communication and coordination required with the Owner.
      - .3.1.1.4 Pressure, flow, and velocity calculations; Indicate inlet pressure from the system, reduced pressure from pressure drop device, and pressures through the system including outlet pressure of system. For all these points, indicate corresponding velocity and Cleaning Force Ratio. Include diagram of the flow pattern to reference calculation points.
      - .3.1.1.5 Acceptance criteria for each type of blow.
    - .3.2 Drawings of the following:
      - .3.2.1 Process flow diagrams depicting the steam blow traveling through piping to be blown and through the temporary piping.
      - .3.2.2 Isometric drawings depicting the piping to be steam blown. Include the temporary piping leading to the outside exhaust noise reduction system for the steam blows.
    - .3.3 Maximum noise levels that will be emitted by the steam blow process.
    - .3.4 Steam blow service company's qualifications as described in Paragraph Quality Assurance below.
- .4 QUALITY ASSURANCE
  - .4.1 A steam target blow shall be considered for all new steam piping, 4 inches NPS and above, to remove general construction debris, organic materials, weld slag, rust and mill scale.
  - .4.2 The risk of equipment damage downstream from newly installed steam pipe shall be assessed to determine if a steam blow is required or other steps shall be specified to protect equipment.
  - .4.3 Qualifications for Steam Blow Service Company

- .4.3.1 Only firms experienced in performing steam blows in noise sensitive areas for projects similar to the requirements specified for this Project shall be considered.
  - .4.3.2 The proposed service company that will perform the steam blows shall submit a list of projects where they have performed steam blows in noise-sensitive areas for projects of similar size to this project. The list shall include a brief description of the scope of work for each project, including the size of equipment blown, the facility name and location, and a contact name and telephone number for each facility. The name of a Contractor will not be acceptable. For each project, provide a brief description of the noise sensitive issues, what was done to satisfy the requirements, and the general results of the noise sensitive issues. Failure to provide qualifications in this format will result in a total rejection of the proposed service company.
  - .4.3.3 The qualifications of the proposed steam blow service will be reviewed by the Engineer.
- .4.4 Regulatory Requirements: All temporary piping systems and design shall be in accordance with ASME B31.1 Power Piping Code.

#### PART 2 - PRODUCTS

##### .1 GENERAL

- .1.1 Products provided under this Section are temporary. The Contractor and the service company shall ensure that all products are safe to use for the service and that no harm will be done to equipment which exists or will remain.
- .1.2 Temporary products used under this Section can be re-used in this Contract provided items remain properly identified at all times.

#### PART 3 - EXECUTION

##### .1 SCOPE OF SERVICE FOR STEAM BLOWS

###### .1.1 General:

- .1.1.1 The Contractor shall obtain and pay for the service of a company to perform the steam blow services.
  - .1.1.2 All steam blows shall occur before each line is placed in service for the first time.
- .1.2 Steam Blow Service Company Responsibilities:
- .1.2.1 The steam blow service company shall design a system to perform steam blowing that satisfies the requirements listed, erect and provide temporary piping and mufflers, and oversee the steam blow procedure.
  - .1.2.2 The steam blow service company shall provide all required temperature and pressure gauges, hoses and valves. They shall also provide any device used to reduce the pressure (if necessary) to obtain a CFR as specified.
  - .1.2.3 Fully coordinating with University requirements for phasing.

- .1.2.4 Clear communication with operating personnel for the operation of the University personnel.
- .1.2.5 Submitting a written plan and procedure for performing steam blow operations.
- .1.2.6 Conducting steam blow operations in a safe manner.
- .1.2.7 Performing and submitting an ASME B31.1 thermal stress analysis of the vent piping system from the last permanent anchor to the vent silencer which shall be anchored.
- .1.3 Contractor Responsibilities: The Contractor shall be fully responsible for all other associated support to the steam blow service company including providing manpower and covering the costs of the following:
  - .1.3.1 Provide temporary services required for steam blowing including service water piping, drain piping, and any other piping or components.
  - .1.3.2 Craft labor and supervision for system preparation, unloading steam blow service company equipment, installing vent piping and equipment, operating valves, support during steam blow service, and disassembly and reloading of piping and equipment
  - .1.3.3 Any connections required for vent or drain piping.
  - .1.3.4 Modifications and repairs to permanent fixtures such as handrails or openings in wall for vent piping if required
  - .1.3.5 Posting of safety warnings and barriers
  - .1.3.6 Temporary insulation of vent piping to protect personnel from hot vent piping
  - .1.3.7 Radio communication with control room operators
  - .1.3.8 Reviewing all of the steam blow service company's procedures to ensure that the conditions of this specification are satisfied
  - .1.3.9 Field verification of temporary equipment/piping layout drawings
  - .1.3.10 Temporary pipe supports of all associated piping systems
  - .1.3.11 All other support and materials required to perform steam blowing
  - .1.3.12 Submitting a written plan and procedure for performing steam blow operations
  - .1.3.13 Ensuring steam blow operations are conducted in a safe manner
  - .1.3.14 Opening all steam trap drip leg vents prior to steam blow and closing them after steam blow is closed
- .2 STEAM TARGET BLOW
  - .2.1 Perform steam target blow for all new steam piping, 4 inches NPS and above, to remove general construction debris, gross debris, organic materials, weld slag, rust, and mill scale. Scope shall cover all piping in Bid Package 1, Bid Package 2, and Bid Package 3, from McCracken Power Plant to the South Campus Central Chiller Plant.
  - .2.2 Procedure and Acceptance Criteria:
    - .2.2.1 Steam blowing may be performed after hydrostatic testing is performed.

- .2.2.2 Remove all meters and instrumentation taps into lines prior to steam blowing. If required by the steam blow process, provide other temporary means to measure steam flow during the steam blow.
  - .2.2.3 The University will only allow the usage of up to 45,000 PPH of steam (approximately 180 PSIG at 580°F with maximum conditions being 200 PSIG at 600°F). Provide an orifice plate or similar flow-restricting device such as a globe valve upstream of the pipe segment to be blown to limit flow as described below. Submit calculations to support this requirement.
  - .2.2.4 Blow each pipe segment a minimum of three separate times with cool down periods between to allow the inside temperature of the pipe to drop by 150°F (may be as much as 4 hours) to cause thermal cycling of piping. This is to facilitate the release of weld slag and other bonded debris. Thermal cycling may be performed prior to the commencement of steam blowing.
  - .2.2.5 The mass velocity head developed during these blows must meet a Cleaning Force Ratio (CFR) of 1.0 or greater where  $CFR = (Q_{sb}^2 \times V_{sb}) / (Q_{co}^2 \times V_{co})$  where  $Q_{sb}$  = steam flow during steam blow (lb/hr),  $V_{sb}$  = specific volume during steam blow (ft<sup>3</sup>/lb),  $Q_{co}$  = steam flow during maximum continuous operation (lb/hr), and  $V_{co}$  = specific volume during maximum continuous operation. For these calculations,  $V_{co} = 3.08$  ft<sup>3</sup>/lb. For 16" NPS pipe,  $Q_{co} = 300,000$  lb/hr, for 14" NPS pipe,  $Q_{co} = 225,000$  lb/hr, and for 12" NPS pipe,  $Q_{co} = 185,000$  lb/hr. Operating at reduced pressure will use less steam and therefore waste less make-up water so this is preferred. The CFR shall be greater than 1.0 for the beginning of the pipe to the end. Try to limit velocities through the permanent piping at the end of the segments to no more than 1,000 ft/sec.
  - .2.2.6 The first two blows shall last for 15 minutes after the CFR has achieved 1.0 or greater. During the third blow, insert a polished brass target in the vent steam path, and blow at CFR 1.0 or greater for a minimum of 15 minutes. The cleanliness level is passed and the blow can end when there are no impacts larger than 0.8 mm diameter and fewer than 10 impacts with a diameter of 0.3 mm to 0.8 mm. Turn over brass targets to Owner.
  - .2.2.7 No permanent valves shall be used to throttle the flow upstream or downstream of the pipe segment being blown.
- .2.3 Other:
- .2.3.1 The steam blows shall be witnessed by the University and A/E.
  - .2.3.2 The steam blows shall not be conducted when the ambient air temperature is less than 50°F because of the campus demand for steam. All line steam blow activities shall be scheduled with University personnel. The scheduling of live steam blow activities is dependent on campus steam demand and steam availability.



- .2.3.3 The exhaust end of the line(s) being blow shall be muffled and quenched. Providing the piping is the responsibility of the Contractor.
- .2.3.4 Steam discharge shall not produce shock waves or air borne particulate which could settle on parked cars, people, buildings, etc. This includes very small particulate which may soil clothing, buildings, cars, etc.
- .2.3.5 The arrangement of the temporary piping shall be designed in accordance with ASME B31.1. The piping arrangement and steam blow shall not cause the stress levels in any permanent or temporary piping component to exceed the allowable levels per ASME B31.1.
- .2.3.6 Any low points created as a result of the temporary piping arrangement shall have manual drains installed for proper drainage during the blow. If the drains are installed in permanent piping they shall be installed in accordance with the permanent piping standards, and shall remain. If they are temporary, to be removed after the steam blow, they may be of suitable temporary construction, such as threaded brass or bronze valves.
- .2.3.7 Modifications to any permanent fixtures or systems to accommodate the steam blow shall be repaired and/or replaced at the completion of the event to the satisfaction of the University and Engineer.
- .2.3.8 The Contractor shall provide barricades, warning tapes, and signage as necessary to secure the immediate area during the steam blows.
- .2.3.9 The Contractor and his cleaning sub-contractor shall provide all necessary temporary piping, valves, mufflers, etc. needed to accomplish the steam blows safely and within the guidelines of this specification.

.3 NOISE ISSUES

- .3.1 General: The steam distribution system is located in a noise sensitive campus community. Noise generated from all steam blow procedures shall be in accordance with the criteria listed herein.
- .3.2 Noise Criteria: Noise levels due to the steam blow shall not exceed 95 dB at a distance of 50 feet from the steam vent point. Provide a silencer at the end of the steam blow vent. Ensure that it is anchored and will be secure during the steam blows. City water is available for quenching the exhaust flow to minimize noise and reduce the velocity of the flow into the silencer, however, the Contractor has to provide a temporary water meter and backflow preventer, and has to provide the hoses needed to get the water where it needs to go. In addition, the Contractor has to coordinate with the University for the availability of water during the steam blow activities to not draw down campus pressure.
- .3.3 Hours of Steam Blow: The hours of steam blowing shall be restricted to times approved by the University. No steam blowing shall occur on holidays.

Further restrictions may be applied by the University. Coordinate timing of testing with University.

- .3.4 The Contractor shall request permission in writing to the University to perform steam blow operations a minimum of 7 days prior to the proposed start of steam blow operations. The request shall include a description of the operations and activities, services and pipe sections affected and the proposed date, time and duration of operations. Steam blow operations shall commence only after the approval of the University.

33 63 20 METERS AND GAUGES

PART 1 - GENERAL

.1 RELATED DOCUMENTS

- .1.1 Contract Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- .1.2 Requirements of the following Specification Sections apply to this Section:
  - .1.2.1 Section 33 63 10 - COMMON WORK RESULTS FOR PIPING
  - .1.2.2 Section 33 63 35 – VALVES

.2 DESCRIPTION OF WORK

- .2.1 This Section provides the specification for pressure gauges.
- .2.2 All devices supplied, whether free-standing or provided as part of a packaged equipment unit, shall satisfy the requirements of this Section.

.3 SUBMITTALS

- .3.1 Shop Drawings and Product Data: All submittals of this Section shall also be incorporated into the operations and Maintenance Manual, including ISA forms. In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
  - .3.1.1 Pressure Gauges: Provide manufacturer's catalog cut sheets for each type of pressure gauge with range, accuracy, materials, and accessories marked clearly.
- .3.2 Operation and Maintenance Manuals: In accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS, submit the following:
  - .3.2.2 General maintenance data for all devices including calibration and troubleshooting

.4 DELIVERY, STORAGE, AND HANDLING

- .4.1 Store thermometers and pressure gauges in a dry location, away from the weather, dust, and debris.
- .4.2 Retain shipping flange protective covers and protective coatings during storage.
- .4.3 Inspect items immediately upon arrival and report any irregularities or damage immediately to the manufacturer/supplier and A/E.

.5 QUALITY ASSURANCE

- .5.1 Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of gauges and meters.
- .5.2 Conform to ASME B31.1 for all installations.
- .5.3 Certification: Provide gauges whose accuracies are certified by the manufacturer for the specified operating conditions.
- .5.4 Single-source Responsibility: Obtain each category of pressure gauges from one source and by a single manufacturer.

## PART 2 - PRODUCTS

### .1 PRESSURE GAUGES

- .1.1 Type: ASME B40.1, Grade A, Type 316 stainless steel, phosphor bronze bourdon-tube pressure gauge, with bottom stem mounted connection.
- .1.2 Case: Phenol with glass lens. Diameter shall be 3-1/2".
  - .1.2.1 Connector: Steel with 1/2 inch male NPT.
- .1.3 Scale: White coated aluminum background with permanently marked black etchings.
- .1.4 Range: Units shall appear in PSIG units. For HPS service, range shall be 0 to 300 PSIG. For PC service, range shall be 0 to 150 PSIG.
- .1.5 Accuracy: Per ASME B40.1, accuracy Grade A.

### .2 PRESSURE GAUGE ACCESSORIES

- .2.1 Isolation Valves: For all pressure gauges in the HPS system, provide 1/2 inch NPS shutoff valve, Class 800 valves suitable for 200 PSIG, 600°F operating steam conditions. Valves shall have a socket welded connection on one end and a threaded connection on the other. Valves shall be located minimum 2 inches outside of insulation. Basis of Design: Velan C032064C-13TY
- .2.2 Syphon: On water systems operating above 120° Fahrenheit and for all steam systems, provide fabricated coil syphon or "pig tail" constructed as specified for the specific piping system in Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.
- .2.3 Snubbers: Do not provide for this project.

## PART 3 - EXECUTION

### .1 GENERAL

- .1.1 Location and orientation of all temperature and pressure gauges shall be coordinated with the A/E prior to installation.

### .2 PRESSURE GAUGE INSTALLATION

- .2.1 Install pressure gauges in pipe coupling or tee as required. Provide shutoff valve, snubber, and/or syphon as specified. Locate pressure gauge in most readable position.
- .2.2 Install where indicated in the Contract Documents.
- .2.3 Isolation valve shall be installed with the threaded end towards the pressure gauge.

.3 ADJUSTING AND CLEANING

- .3.1 Calibrate gauge according to manufacturer's written instructions, after installation.
- .3.2 Adjusting: Adjust faces of gauges to proper angle for best visibility.
- .3.3 Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touchup paint.

.4 PROCESS CONNECTIONS

- .4.1 Contractor shall provide all process connections in piping systems to accommodate gauge installation. Process connection type shall be selected by the Contractor to match the actual gauge provided.

33 63 25 PIPING SPECIALTIES

PART 1 - GENERAL

.1 RELATED DOCUMENTS

- .1.1 Contract Drawings and general provisions of Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- .1.2 Requirements of the following Specification Sections apply to this Section:
  - .1.2.1 Section 33 63 05 - GENERAL PIPING PROVISIONS
  - .1.2.2 Section 33 63 10 - COMMON WORK RESULTS FOR PIPING
  - .1.2.3 Section 33 63 20 - METERS AND GAUGES
  - .1.2.4 Section 33 63 35 - VALVES
  - .1.2.5 Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT
  - .1.2.6 Section 33 63 45 - GASKETS
  - .1.2.7 Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT
  - .1.2.8 Section 33 63 55 - PIPING INSULATION

.2 DESCRIPTION OF WORK

- .2.1 This Section provides the specification for pipe specialties. Specialties include steam traps, dirt pockets/drip legs, strainers, automatic air vents, pipe sleeves, and pipe sleeve seals.
- .2.2 Provide pipe sleeves where piping passes through manhole walls (where detailed), vault walls/roofs, tunnel walls/roofs, metal gratings, trench covers, roofs, and concrete floor.
- .2.3 Provide steam traps at all low points in the steam piping system where condensate can collect, as designated on the Contract Drawings. The Contractor shall notify the A/E of low points that are created in the piping system so that a steam trap station can be added. The Contractor shall avoid such low points as physical space limits.

.3 SUBMITTALS

- .3.1 Shop Drawings and Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
  - .3.1.1 Steam Traps: Manufacturer's product data including:

- .3.1.1.1 Type
- .3.1.1.2 Materials of construction with drawing and design rating
- .3.1.1.3 Performance based on specified differential pressure and size
- .3.1.2 Steam Trap Valve Station: Manufacturer's product data including:
  - .3.1.2.1 Type
  - .3.1.2.2 Materials of construction with drawing and design rating
- .3.1.3 Strainers: Manufacturer's product data including:
  - .3.1.3.1 Drawing showing type and dimensions of strainer
  - .3.1.3.2 Materials of construction for body and mesh
  - .3.1.3.3 Design rating
  - .3.1.3.4 Mesh size and pressure drop versus flow curve
- .3.1.4 Pipe sleeve schedule indicating system location and size of pipe sleeve.
- .3.1.5 Manufacturer's product data for all materials to be used.
  
- .3.2 Operation and Maintenance Manuals: In accordance with Section 01 78 00 – CLOSEOUT SUBMITTALS, submit the following:
  - .3.2.1 Maintenance data and spare parts list for:
    - .3.2.1.1 Steam traps
    - .3.2.1.2 Steam trap valve stations
    - .3.2.1.3 Strainers
  
- .4 QUALITY ASSURANCE
  - .4.1 Comply with the following for steam piping and accessories:
    - .4.1.1 ANSI/ASME B31.1: Power Piping
    - .4.1.2 ANSI/ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 - Unfired Pressure Vessels
    - .4.1.3 MSS - Manufacturers Standardization Society
    - .4.1.4 UL Listed: Provide UL listed fire separation assemblies
    - .4.1.5 NFPA: National Fire Protection Association Codes and Standards

PART 2 - PRODUCTS

.1 STEAM TRAPS

.1.1 General

- .1.1.1 Refer to the Contract Drawings for details of the steam trap stations which include the drip leg, drip leg valve, steam trap, and all steam trap related items.
- .1.1.2 Provide steam condensate traps at locations indicated on the Contract Drawings and of type as indicated in the "Steam Trap Schedule" listed in the Contract Drawings. The capacity of the steam trap provided shall satisfy the design flow listed on the "Steam Trap Schedule" for both the operating and maximum conditions of pressure, differential pressure, and steam temperature. Connection sizes of traps are provided as a basis of design; however, actual sizes are dependent upon the actual selection of the steam trap.

- .1.1.3 Steam trap sizing selection and location is based on the piping layout as presented in the Contract Drawings. The Contractor is responsible for informing the A/E of any piping layout changes which could affect the sizing, selection, and location of the steam traps.
- .1.1.4 Steam traps shall be provided at all low points in the steam piping system where condensate can collect, upstream of isolation valves and a maximum spacing of one per every 500 lineal feet of steam pipe.
- .1.2 Steam Main Distribution – HPS
  - .1.2.1 Service: For HPS steam mains. The normal operating conditions are 185 PSIG at 585°F. The maximum operating conditions are 200 PSIG at 600°F. Traps shall be designed for service where the discharge of the trap is sub-cooled condensate water between 140 to 210°F.
  - .1.2.2 Performance: Refer to "Steam Trap Schedule" listed in Contract Drawings. The trap shall be rated for maximum back pressure of 99 percent of inlet pressure.
  - .1.2.3 Construction:
    - .1.2.3.1 General: Traps shall be thermodynamic style. All components shall be designed for maximum allowable steam pressure of 300 psig, 625°F, with maximum operating pressure of 300 psig.
    - .1.2.3.2 Body and Cover: Stainless steel
    - .1.2.3.3 Disc: Stainless steel
    - .1.2.3.4 Cap: Stainless steel
  - .1.2.4 Connections: Size of connection shall depend on the flow requirements. Type of connection shall be universal connector.
  - .1.2.5 Acceptable Manufacturers: Spirax Sarco or Armstrong. The strainer specified below shall be provided by the steam trap manufacturer and must satisfy the specification below.
  - .1.2.6 Basis of Design: Armstrong CD-3300.
- .2 STEAM TRAP VALVE STATIONS
  - .2.1 Service: For HPS steam mains. The normal operating conditions are 185 PSIG at 585°F. The maximum operating conditions are 200 PSIG at 600°F.
  - .2.2 Description: Refer to Steam Trap Station with two isolation valves, integral strainer with blowdown valve, test valve, and steam trap connection.
  - .2.3 Construction:
    - .2.3.1 General: All components shall be designed for maximum allowable steam pressure of 300 psig, 625°F.
    - .2.3.2 For valve selection see BDS 33 63 35.3, Valve Group 3
    - .2.3.3 Strainer Screen: Stainless steel
  - .2.4 Connections: 3/4-inch socket welded connections for pipe; Universal trap connection for steam trap.

- .2.5 Acceptable Manufacturers: Shall be provided by the steam trap manufacturer.
- .2.6 Basis of Design: Armstrong TVS Connector.
  
- .3 STRAINERS - STEAM TRAP SERVICE
  - .3.1 Strainers for steam service shall be "Y" type, unless otherwise indicated on Contract Drawings. Strainers for steam traps stations shall be in accordance with this specification.
  - .3.2 Provide a screen blowdown valve for each strainer. The valve shall be the full size of the blow-off tap. Provide shut-off valve in accordance with Section 33 63 35 - VALVES. Provide nipple with cap downstream of valve in accordance with the pipe system specification as specified in Section 33 63 10 - COMMON WORK RESULTS FOR PIPING. Select the length of the nipple connecting the blow-off valve to the strainer basket connection so that the blow-off valve is clear of the insulation.
  - .3.3 Provide strainer screen with a minimum net free area of 2-1/2 times the cross-sectional area of the entering pipe.
  - .3.4 All strainer screens shall be 1/8 inch thick Type 304 or 316 stainless steel with 3/64-inch mesh perforations unless otherwise required by the valve or device which it protects.
  
- .4 PIPE SLEEVES
  - .4.1 For concrete or masonry interior and exterior walls and floors, partitions, and fire-rated walls (Where Detailed)
    - .4.1.1 Fabricate sleeves or floor from Schedule 40 steel pipe in length to match finished wall or floor thickness. Provide a continuous 2 inch wide x 1/4 inch thick steel anchor plate and water stop weld to sleeve.
    - .4.1.2 For pipes 8 inches NPS diameter and smaller, make sleeve inside diameter a minimum of 2 inches larger than the outside diameter of the pipe insulation. For pipes larger than 8 inch NPS, make sleeve inside diameter a minimum of 3 inches larger than the outside diameter of the pipe insulation. Coordinate with the calculations made by the requirements of Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT which shall calculate thermal movements of piping. Provide a greater clearance where dictated by these calculations.
    - .4.1.3 Sleeves shall be hot-dipped galvanized.
    - .4.1.4 Where the service pipe insulation is combustible the pipe shall be un-insulated where passing through fire-rated walls and partitions. For service pipes with non-combustible insulation systems the insulation shall extend through the wall.
  
  - .4.2 For Metal Grating and Trench Covers Penetrations
    - .4.2.1 All grating penetrations shall be banded with 1-1/4 inch wide by 1/4 inch thick steel bands welded to all of the cut grating bars or plate.

- .4.2.2 Opening inside the band shall be the diameter of the pipe or the insulation plus a minimum of 2 inches. Coordinate with the calculations made by the requirements of section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT which shall calculate the thermal movements of piping. Provide a greater clearance where dictated by these calculations.
- .4.3 Mechanical Type (Synthetic Rubber) - Watertight Pipe Sleeves
  - .4.3.1 General: Provide for all piping penetrations through exterior walls to below ground areas.
  - .4.3.2 Description: The pipe to wall penetration closures shall be "Link-Seal" as manufactured by Thunderline Corporation - Belleville, Michigan or equal. Seals shall be high temperature rated for 400°F. Seals shall be modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide an absolutely water-tight seal between the pipe and wall opening. The seal shall be constructed so as to provide electrical insulation between the pipe and wall, thus reducing cathodic reaction between these two members. Material shall be silicone and shall be rated for sustained temperature of 325°F.
- .4.4 Fire Rated Sleeve Seals
  - .4.4.1 Provide UL listed fire rated pipe sleeve seals and assemblies at fire rated partitions. Install fire rated sleeve seals in accordance with the manufacturer's instructions and the listing requirements.
  - .4.4.2 Fire rating shall be as required for partition rating but not less than 1-1/2 Hours.
- .4.5 Non-Rated and Non Watertight Penetration Pipe Sleeves
  - .4.5.1 Openings and sleeve for piping shall be large enough to allow lateral thermal movement of the piping. The calculations made by the requirements of Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT shall indicate the minimum required clearance.
  - .4.5.2 If it is observed for any new piping system that the pipe insulation (or pipe wall, if there is no insulation) is touching the pipe sleeve when the pipe is heated, the Contractor shall provide a larger pipe sleeve at no additional cost to the University.

PART 3 - EXECUTION

.1 INSTALLATION - GENERAL



- .1.1 Install steam specialties in accordance with manufacturer's instructions and as shown on the Contract Drawings.
- .2 INSTALLATION - STEAM TRAPS
  - .2.1 Provide all steam trap accessories in accordance with the details on the Contract Drawings.
  - .2.2 Provide drip legs with sizes indicated on Contract Drawings.
  - .2.3 Install steam traps at an elevation with respect to the drip leg in accordance with the manufacturer's instructions to insure hydraulic head during start-up.
  - .2.4 Install steam traps at all low points in the steam piping system where condensate can collect, upstream of isolation valves and a maximum spacing of one (1) per every 500 lineal feet of steam pipe.
- .3 INSTALLATION OF STRAINERS
  - .3.1 Install strainers where indicated and at places not indicated but where required by a manufacturer's instruction to protect his equipment.
  - .3.2 Install steam strainers horizontally on their side with screen chamber at the 3 or 9 o'clock position. Install all other strainers horizontally with the screen chamber at the 6 o'clock position. Provide blowdown drain with valve and cap. Install strainers vertically only when required and when the direction of flow is down.
- .4 INSULATION, PAINTING AND, IDENTIFICATION OF STEAM SPECIALTIES
  - .4.1 Insulate all pipe specialties in accordance with Section 33 63 55 - PIPING INSULATION. Do not insulate moving parts unless insulation sleeves are provided. Do not insulate steam traps.
  - .4.2 Provide steam trap identification tags in accordance with Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.
- .5 INSTALLATION OF PIPE SLEEVES
  - .5.1 Extend and partition sleeves through and cut flush with each surface, unless otherwise indicated or specified.
  - .5.2 Locate piping in sleeve to allow for movement. Do not allow steel sleeves to touch copper piping at any time.
  - .5.3 After piping has been installed (and insulated if required), fill the annular spaces between piping and sleeves with materials as specified in this Section.
  - .5.4 Sleeves shall be fabricated and hot dipped galvanized, cold galvanizing coating shall be applied for any field touchup repairs.
  - .5.5 Fill all voids between the sleeve and the rough wall opening with non-shrinking non-metallic epoxy grout as specified in Section 03 30 00 - CAST-IN-PLACE CONCRETE.
  - .5.6 Terminate floor and trench cover sleeves at 1/2 inch above the finished floor or cover.
- .6 INSTALLATION OF PIPE SLEEVE SEALS
  - .6.1 For Pipe Sleeves Receiving Non-Fire-Rated Seals (Watertight Pipe Sleeves)

- .6.1.1 Provide and install mechanical type rubber link type as detailed and as manufactured by Thunderline Corporation or equivalent.
  - .6.1.2 Size the link seal as recommended by the manufacturer and as required for the intended service.
  - .6.1.3 The link seal shall be installed so that tightening bolts are accessible for maintenance.
  - .6.1.4 For insulated piping systems provide a 6-inch long removable portion in front of the tightening bolts for maintenance. Do not extend insulation through the sleeve.
  - .6.1.5 Pack the void between the pipe and the sleeve with oakum and caulk on the non-servicing side of the sleeve.
- .6.2 Provide UL listed fire rated pipe sleeve seals and assemblies at fire rated partitions. Install fire rated sleeve seals in accordance with the manufacturer's instructions and the listing requirements.

33 63 30

PIPE EXPANSION JOINTS

PART 1 - GENERAL

.1 RELATED DOCUMENTS

- .1.1 Contact Drawings and general provisions of the Contract, including the General and Supplementary Conditions and Division 1 Specification Section, apply to this Section.
- .1.2 Requirements of the following specification Sections apply to this Section.
  - .1.2.1 Section 33 63 05 - GENERAL PIPING PROVISIONS
  - .1.2.2 Section 33 63 10 - COMMON WORK RESULTS FOR PIPING
  - .1.2.3 Section 33 63 40 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT
  - .1.2.4 Section 33 63 45 - GASKETS
  - .1.2.5 Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT
  - .1.2.6 Section 33 63 55 – PIPING INSULATION
  - .1.2.7 Section 33 63 35 – VALVES

.2 DESCRIPTION OF WORK

- .2.1 This Section includes pipe expansion joints and expansion joint insulation blankets for mechanical piping systems.

.3 SUBMITTALS

- .3.1 Shop Drawings and Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
  - .3.1.1 Product data for each type of pipe expansion joint specified. Provide design data and materials description.
  - .3.1.2 Pipe expansion joint schedule showing manufacturer's figure number, size, location, and features for each required expansion joint. Indicate country of fabrication and ISO 9001 registry, if applicable. Provide calculations of each joint per EJMA 9th edition standard including stresses, cycle life, joint spring rates, etc.

- .3.1.3 Assembly - type shop drawings for each pipe expansion joint, indicating dimensions, weights, required clearances, pipe alignment tolerances and methods of component assembly.
- .3.1.4 Assembly drawing of insulation blankets
- .3.1.5 Individual expansion joint piping configuration diagrams indicating basic piping configuration between anchors, pipe anchor spacing requirements, guide spacing and guide pipe travel requirements.
- .3.1.6 Maintenance data for each type pipe expansion joint specified to include in the "Operating and Maintenance Manuals" specified in Section 01 78 00 – CLOSEOUT SUBMITTALS.

.4 QUALITY ASSURANCE

- .4.1 All materials provided shall be designed, fabricated, installed, and tested in accordance with ASME B31.1.
- .4.2 All expansion joints shall be designed and installed in accordance with the 2008 9th edition of Expansion Joint Manufacturer's Association (EJMA) Standards.
- .4.3 Expansion joint shall be fabricated and assembled in the United States or Canada, or the expansion joints must be manufactured by an ISO 9001 registered corporation. No expansion joints shall be provided where materials are fabricated or assembled in China including Taiwan, regardless of ISO 9001 registry.

.5 DELIVERY, STORAGE, AND HANDLING

- .5.1 Handle expansion joints with great care. Adhere to the requirements of the manufacturer.
- .5.2 Do not break the shipping tabs off the expansion joint until it is installed and all piping to the adjacent anchors including the anchors are completed.

PART 2 - PRODUCTS

.1 EXTERNALLY PRESSURIZED EXPANSION JOINTS (METAL-BELLOWS, PACKLESS TYPE)

- .1.1 Type: Provide packless bellows expansion joints of externally pressurized design where designated for thermal expansion.
- .1.2 Steam Service:
  - .1.2.1 Design: Expansion joints shall be rated for 200 PSIG, 600°F steam service. Joints shall be designed for 1,000 full pressure/temperature cycles to the 200 psig, 600°F steam rating. Provide axial movement as indicated in the table on the drawings. Non-axial movement shall be minimal due to the internal/external guides of the joint itself and the guides of the piping system. Each joint must be hydrostatically tested by the manufacturer prior to shipping at 350 PSIG for a minimum of 10 minutes.
  - .1.2.2 Materials: Bellows shall be constructed of ASTM A240 Grade 321 stainless steel, of uniform curvilinear shape without circumferential welds, and with not more than one longitudinal weld for each 10 inches of pipe diameter. Bellows shall be multi-ply construction. Provide carbon steel internal and external guide rings per ASTM A36

to maintain alignment of the expanding pipe. Weld bellows to internal and external guide rings via stainless steel collars. Do not weld bellows to the guide rings at the root or crest radii. Provide external housing and internal liner of expansion joint rated for the design conditions and constructed of seamless ASTM A53 Grade B or ASTM A106 Grade B carbon steel to limit bellows movement and prevent flow induced vibration. Vent internal guide rings to reduce the effects of sudden pressure changes. Provide a base for all expansion joints that is designed to serve as an intermediate anchor. Provide a 3000-LB, forged steel, ASTM A105, 2-inch socket welded half coupling with a forged steel pipe plug on the cover at the 6 o'clock position to serve as a steam trap/liquid drain. Provide a lifting lug.

.1.3 Pumped Condensate Service:

.1.3.1 Design: Expansion joints shall be rated for 200 PSIG, 388°F steam service and liquid service of 200 PSIG at 387°F. Joints shall be designed for 1,000 full pressure/temperature cycles to the 200 PSIG, 388°F steam rating. Provide axial movement as indicated in the table on the drawings. Non-axial movement shall be minimal due to the internal/external guides of the joint itself and the guides of the piping system. Each joint must be hydrostatically tested by the manufacturer prior to shipping at 350 PSIG for a minimum of 10 minutes.

.1.3.2 Materials: All wetted parts shall be stainless steel to resist corrosion. Bellows shall be constructed of ASTM A240 Grade 321 stainless steel, of uniform curvilinear shape without circumferential welds, and with not more than one longitudinal weld for each 10 inches of pipe diameter. Bellows shall be multi-ply construction. Provide stainless steel internal and external guide rings to maintain alignment of the expanding pipe. Weld bellows to internal and external guide rings via stainless steel collars. Do not weld bellows to the guide rings at the root or crest radii. Provide external housing and internal liner of expansion joint rated for the design conditions and constructed of Type TP316L seamless stainless steel conforming to ASTM A312 to limit bellows movement and prevent flow induced vibration. Vent internal guide rings to reduce the effects of sudden pressure changes. Provide a base for all expansion joints that is designed to serve as an intermediate anchor and vertical support. Provide a 3000-LB, forged steel, ASTM A105, 1/2-inch socket welded half-coupling with a forged steel pipe plug on the cover at the 6 o'clock position to serve as a liquid drain. Provide a lifting lug.

.1.4 Connections: Expansion joints shall have butt weld ends, regardless of size.

.1.5 Acceptable Manufacturers: Provide expansion joints from Hyspan, Microflex, Pathway Bellows, or Senior Flexonics.

- .1.6 Blanket: Insulation/weather covers shall be provided for each expansion joint as specified in this Section.
  - .1.7 Warranty: Expansion Joints shall be provided with a five year minimum warranty against leaks for material defects which shall cover the material replacement. Repair of joint is not acceptable.
  - .1.8 Nameplate: Provide a weatherproof, temperature proof, metal nameplate on the exterior of each expansion joint with all of the following information etched or depressed into the metal: manufacturer, model number, serial number, year fabricated, maximum pressure and temperature rating, design compression and extension of expansion joint, and maximum design full pressure/temperature cycles of the expansion joint.
- .2 INSULATION BLANKETS
- .2.1 General: Provide an insulation jacket for each expansion joint provided. The insulation jacket shall be removable and reusable and shall be designed to expand and contract as necessary with the expansion joint and connected pipe. The contractor shall verify clearance requirements for insulation jackets for expansion joints located in restricted locations including pipe trenches.
  - .2.2 Design
    - .2.2.1 Provide non-porous inner and outer jackets rated for flooding conditions, constructed of minimum 20 ounce per square yard PTFE Teflon film laminated/impregnated Nomex woven cloth. Blanket construction shall be a double woven stitch with a minimum of 7 stitches per inch. No raw cut jacket edges shall be exposed.
    - .2.2.2 Insulation shall be minimum 5-inch thick fiberglass needled mat with minimum 11 lbs/ft density. All materials shall be rated for service of 600°F. Outer jacket wall temperature shall be under 120°F. Submit proof of outer temperature assuming wet conditions.
    - .2.2.3 Type: Provide different blanket style to accommodate features of each joint:
      - .2.2.3.1 Externally Pressurized Bellows Style: Blanket design shall encase the unit to be insulated and provide a minimum 4 inch overlap extension over insulation of adjacent piping at cold conditions. Coordinate requirements for support base mounting conditions for floor mounted and steel rack mounted expansion joints.
    - .2.2.4 To accommodate leaks and detect their origins, blanket pieces shall have either a low point drain grommet or a mating seam at the low point which will allow water to seep through.
    - .2.2.5 Provide means of prevention of shifting of insulation filler.
    - .2.2.6 Provide lacing twists made of durable noncorrosive, non-rotting material for fastening blankets. Velcro is not acceptable. Assembly shall allow removal and installation with no tools required.

PART 3 - EXECUTION

.1 PIPE EXPANSION JOINT INSTALLATION

- .1.1 Dimensions and End Connections: The Contractor is responsible for ensuring that the expansion joints provide conform to the dimensions required by the piping, anchor and pipe guide configuration. Expansion joint end connections shall be butt welded. Welding shall conform to ASME and AWS and examined in accordance with specifications section 33 63 10 – “Common Work Results for Piping”
  - .1.2 Install pipe expansion joints according to manufacturer's written instructions.
  - .1.3 Align expansion joints to avoid end-loading and torsional stress. Metal-bellows expansion joints cannot accept any torsional loading. All expansion joints shall be provided with a base that shall be utilized for vertical support and for installation assistance, leveling shims or leveling bolts with nuts on the underside of the base shall be utilized for leveling and aligning the unit during installation. After alignment, high density calcium silicate insulation shall be inserted between the base and mounting steel or grout between the base and the floor. If a pipe anchor is adjacent to the expansion joint in accordance with the manufacturer's requirements and unless indicated otherwise, the expansion joint support base shall not have tighten nuts or be otherwise permanently fixed or secured to the mounting steel, floor or other parts of the structure.
  - .1.4 Provide insulation/weather cover which protects joints from moisture. Clean inside of expansion joints thoroughly before putting joints into service.
  - .1.5 Do not break shipping band until expansion joint is installed and system is complete from anchor to anchor. If shipping band is broken prematurely, consult Associate and manufacturer immediately.
  - .1.6 Stretching of expansion joints to correct for piping misalignment or to accommodate available end-to-end spacing is not allowed.
  - .1.7 Laser align piping during welding and when aligning all supports, guides, and anchors. Ensure straight alignment so expansion joint will not bind. Follow all directions by expansion joint manufacturer for guide locations, except if a manufacturer states that the first guide closest to the expansion joint (within 4 pipe diameters) is not required, provide anyway.
- .2 EXPANSION JOINT TESTING
- .2.1 Contractor shall hydrostatically test piping system with joints in place after the shipping bands are broken and the entire piping system is connected as one system.
  - .2.2 Under no instance shall new expansion joints be hydrostatically tested, steam blown or put in any kind of service without the entire piping system being connected as one system, including all anchors and guides installed and completed.
  - .2.3 Water utilized for hydrostatic test must be at room temperature when hydrostatic test is performed.
- .3 PIPE ALIGNMENT GUIDE INSTALLATION
- .3.1 Install pipe alignment guides on piping as indicated on contract drawings. Pipe alignment guides shall be provided as indicated on the drawings and in accordance with the Expansion Joint Manufacturer's requirements. If the

Expansion Joint Manufacturer's required installation conditions do not exist, the Contractor shall alert the Associate and the Expansion Joint Manufacturer. Any damage resulting from pipe alignment guides not being located in accordance with the Expansion Joint Manufacturer's requirements shall be the responsibility of the Contractor.

- .3.2 Secure pipe alignment guides to tunnel structures as indicated on the contract drawings.

.4 PIPE ANCHOR INSTALLATION

- .4.1 Install pipe anchors at locations indicated on the drawings and in accordance with pipe anchor details indicated on the drawings. Comply with the Expansion Joint Manufacturer's requirements and recommendations for pipe anchor locations and placement. Notify the Associate of pipe anchor installation conditions that do not conform to the locations indicated on the drawings and the Expansion Joint Manufacturer's requirements or recommendations.
- .4.2 Fabricate and install anchors by welding steel shapes, plates, and bars to piping and securing to structure. Coordinate requirements for pipe anchor - concrete cast-in and embedded structural elements with the concrete work. Comply with ASME B31.1 and with AWS D1.1.
- .4.3 Provide grout for pipe anchors in accordance with 33 63 05 – GENERAL PIPING PROVISIONS.
- .4.4 For hot dipped galvanized pipe anchors provide cold galvanizing repair coating at field welds and for touch-up of damaged galvanized surfaces.

33 63 33

STEAM ENERGY DISTRIBUTION METERING

PART 1 GENERAL

.1 APPLICATIONS:

- .1.1 The main objective of this design standard is to outline the requirements of a steam meter, to measure the consumption of steam supply in total pounds (lbs) and total British Thermal Units (BTU) in the buildings owned by The Ohio State University, and to communicate this consumption locally and to the campus-wide Energy Metering & Monitoring system (InStep eDNA server). The steam meter shall include the instantaneous mass flow rate in pounds per hour (lbs/hr) and totalized mass consumption in pounds (lbs), as well as instantaneous energy flow rate in British Thermal Units per hour (BTU/hr) and totalized energy delivered in British Thermal Units (BTU), with steam pressure and steam temperature compensation.
- .1.2 The steam meter, elements and devices shall meet custody transfer measurement requirements as indicated in Part 2 – PRODUCTS AND Part 3 - EXECUTION of this Section. Custody transfer measurement furnishes quantity and quality information which can be used as the basis for a change in ownership and/or a change in responsibility for materials, e.g., billing for rate of energy demand plus totalized energy transfer.
- .1.3 Products: Describes the general requirements for the totalizing steam meter, primary element, a flow computer, secondary element, and an RTD temperature sensor/transmitter.

.2 DEFINITIONS:

- .2.1 High Pressure Steam: Steam pressures higher than 70 psig.
- .2.2 Medium Pressure Steam: Steam Pressures between 15 psig and 70 psig.
- .2.3 Low Pressure Steam: Steam pressures below 15 psig.

.3 DOCUMENTATION

- .3.1 Data sheets, wiring diagrams, catalog literature, installation instructions, and Operations & Maintenance data must be sent to The Ohio State University Utilities for prior review and approval, to include the primary element flow sensor, secondary element(s) (transmitters, multivariable transmitter, etc.), RTD temperature sensor/transmitter, and flow computer. Instrument sheets as requested in ISA S20 Standard must be submitted.
- .3.2 Interconnections and drawings for installation of the primary, secondary, and tertiary elements of the corresponding devices shall be submitted for review and approval prior to installation. P&ID's shall be furnished in accordance to ISA S5.
- .3.3 Provide flow computer program setup parameters as written hard copy and as Windows based electronic file.
- .3.4 Certificates for the conformance of the steam meter according to engineering procedures and practices, and standards, shall be provided. Temperature and pressure compensation, coefficients, linear regressions, constants, equations, methodologies and basis of calculations to establish the steam flow rates shall also be provided for review.
- .3.5 Certificates of calibration for the steam meter with air or any other gas available in the calibration facility, as well as a certificate of calibration conformance for the transmitters in accordance to NIST shall be provided.

PART 2 PRODUCTS

.1 GENERAL

- .1.1 The selection of the steam meter shall be based on the following parameters and recommendations to guarantee that the accuracy of the steam meter station stays within the  $\pm 1\%$  of the actual reading from 5% to 100% of the maximum rated flow, and the repeatability within  $\pm 0.5\%$ .
- .1.2 The supply pressure could vary between 120 psig and 200 psig, whereas the temperature changes between 370°F and 600°F.
- .1.3 The mass flow rate shall be computed in lbs/hour and the energy flow rate shall be computed in BTU/hr; both shall be temperature and pressure compensated. The steam meter shall register the mass flow rate with no less than 30 to 1 turn down based on actual flow conditions.
- .1.4 Steam meters and associated piping shall be sized for steam velocities between 5 fps and 100 fps unless otherwise specified by the meter manufacturer.
- .1.5 The pressure drop through the primary element, sensor, shall not be greater than 200 inches w.g.c. for the maximum mass flow rate.
- .1.6 The flow computer shall provide loop powered 4-20 mA inputs for the temperature and pressure compensated mass flow rate in lbs/hour and



energy flow rate in BTU/hr. The flow computer shall totalize the mass flow rate, the energy flow rate, and shall be equipped with a MODBUS TCP/IP RTU communications port or MODBUS RTU RS-485 over AWG-18 twisted pair shielded cable to another meter in the same location. Prior to flow computer approval, the flow computer must be submitted by the Contractor for testing by The Ohio State University Utilities to prove interoperability with the campus-wide Energy Metering & Monitoring system (InStep eDNA server). Cat-6 shielded cable and conduit shall be installed between the flow computer or group of flow computers connected by twisted pair and the nearest building network switch.

- .1.7 The flow computer shall be supplied with two isolated outputs that permit external system, e.g. Building Automation Systems, to monitor selected meter parameters.
- .1.8 All primary and secondary electronic elements shall support an ambient temperature equal to or greater than 150°F.
  
- .2 PRIMARY ELEMENT, FLOW SENSOR
  - .2.1 A Variable Area flow sensor either non-spring loaded or spring loaded or an ultrasonic shall be used as the primary element of the steam meter. The material of the components of the flow sensor must be 316 stainless steel or material approved by OSU Utilities. The nominal size of the sensor shall match the size of the pipe where the flow sensor will be installed. The primary element shall comply with standard codes, ISO, ASME.
  - .2.2 For those cases that apply, the flow sensor shall be installed in a wafer or lug type arrangement, constructed of 316 stainless steel, or approved material, rated for 200 psig and 660°F. If the primary flow element is longer than its flange-to-flange dimension, then a spool piece shall be included of sufficient length such as to permit the removal of the primary flow element with spool piece, and eliminate disassembly of any downstream or upstream piping when servicing the element.
  - .2.3 Calculations, equations and/or methodology used to determine the size of the flow sensor shall be supplied to OSU Utilities for acceptance. Where applicable, Reynolds Number dependent equations shall be checked for maximum and minimum mass flow rates.
  
- .3 SECONDARY ELEMENT, TRANSMITTER(S)
  - .3.1 The output shall be 4-20mA with digital signal preferable with HART protocol. The accuracy shall be at least  $\pm 0.1\%$  of span, 4 to 20mA, and  $\pm 0.07\%$  of span, digital. Drift less than  $\pm 0.1\%$  of URL over at least 8,000 hours.
  - .3.2 Range limits for the differential pressure measurement shall be 0 to 200 inches of H<sub>2</sub>O with a minimum transmitter pressure rating of 300 psi. Range limits for absolute pressure shall be 0 to 300 psia. The transmitter shall be energized with a 24-VDC source or a 120-VAC source for flow computers. The differential pressure transmitter shall be mounted below the flow element using 316 stainless steel tubing.

- .3.3 Programming shall be accomplished via a Windows-based software package or from the keypad of the flow computer without the need to open the cover; thus maintaining the NEMA 4 integrity of the enclosure.
  - .3.4 Standard LCD indicator with backlight shall be included with the flow computer.
  - .3.5 The flow computer shall provide precise and reliable measurement of absolute/gauge and differential pressures, sensor and electronics temperatures, and process temperature from an external transmitter/RTD combination. It shall calculate densities and specific enthalpies according to the Steam Tables ASME 1997, and mass flow rates for the actual pressure and in line temperature. Parameters and measurements shall be stored in non-volatile memory to avoid data loss during power failure. Data shall be restored from internal memory upon restoration of power.
  - .3.6 A 316 stainless steel 3-valve manifold to mount the pressure differential transmitter shall be supplied. Drain/vent material and isolation valves shall be 316 stainless steel and furnished.
- .4 PROCESS CONNECTIONS AND PIPING
- .4.1 All steam service piping shall comply with the requirements of ASME 31.1 Power Piping Code.
  - .4.2 Sensor connections that are normally NPT 1/4-inch shall be adapted to 1/2-inch.
  - .4.3 Sensor connections shall be minimum 1/2-inch, 316 stainless steel, heavy duty, schedule 80 pipe or 1/2-inch diameter 316 stainless steel tubing with compression fittings,
  - .4.4 Pipe sealants for threaded connections shall be rated for a minimum of 600°F.
  - .4.5 Process shutoff valves shall be supplied for all sensor connections, minimum 1/2-inch, class 600, 316 stainless steel, and full port gate style with graphite packing, Velan or approved equal.
  - .4.6 All pressure-sensing devices shall have a condensate loop (i.e. pigtail).
- .5 RTD TEMPERATURE SENSOR/TRANSMITTER
- .5.1 Furnish a spring loaded Dual Element 100 ohm platinum RTD temperature sensor assembly. The accuracy shall be  $\pm 0.5\%$  at 32°F utilizing a three-wire single element with aluminum waterproof head, 316 stainless steel nipple-union-nipple extension. The length shall be determined by the piping system where the meter will be installed.
  - .5.2 The temperature process input range shall be 20°F to 800°F.
  - .5.3 The thermo-well shall be 316 stainless steel, long enough for the size of the process pipe with a 4-inch lagging allowance, and provided with a 3/4-inch NPT process connection. The well finish shall be 15Ra maximum, electro-polish finish.
- .6 STEAM METER MANUFACTURERS AND MODELS
- .6.1 Spirax/Sarco ILVA flow sensor with Steam Flow Computer, including pressure transmitter, temperature sensor and transmitter, differential pressure transmitter and accessories including but not limited to flow straighteners.

- .6.2 GE Panameterics Transient Time Ultrasonic steam flow meter, including flow computer, and pressure and temperature transmitters for flow compensation.
- .6.3 McCrometer V-Cone flow sensor with flow computer, including pressure transmitter, temperature sensor and transmitter, differential pressure transmitter and accessories. Acceptable in limited applications where the turndown of the steam flow is relatively low, 10 to 1.
- .6.4 Kessler-Ellis Products (KEP) flow computer shall be supplied.
- .6.5 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents.
- .6.6 All meters will be considered for approval on the basis of life cycle cost analysis by the A/E.

.7 DIFFERENTIAL PRESSURE AND PRESSURE TRANSMITTERS - MANUFACTURERS

- .7.1 Rosemount
- .7.2 Honeywell
- .7.3 Siemens

.8 MANUFACTURERS

- .8.1. RTDs shall be specified as Burns Engineering Series 200
- .8.2. Temperature Transmitters shall be specified as HART SensorTec model Q4, PR Electronics Model 5335A, or Rosemount model 248.

PART 3 EXECUTION

.1 CERTIFICATIONS – CALIBRATION AND CALCUALTIONS

- .1.1 A third-party conformance certificate for the calibration of the steam meter shall be provided.
- .1.2 A certified calculation, for the maximum and minimum mass flow rates at 185 psig and 540°F shall be supplied.
- .1.3 Calibration of the transmitter(s) shall be accomplished following NIST standards. A certification of conformance shall be submitted.

.2 COMMUNICATION

- .2.1 Meter data in the form of total consumption, mass flow rate, energy flow rate, and a meter diagnostic must be communicated over the university Ethernet network back to the InStep eDNA server. Consumption will be in billable units, klbs of steam and kBTUs of steam. Flow rate will be in klbs/hr of steam. Meter diagnostic will be in the form of Normal or Failure. MODBUS data registers shall be provided, at a minimum, for instantaneous mass flow rate, energy flow rate, totalized mass and energy values, temperature, pressure, and differential pressure.  
Meters will utilize a combination of MODBUS RTU over RS-485 and MODBUS over Ethernet. Provide a B&B Model MESR901 RS-485 to Modbus TCP/IP converter for flow computers without built in Modbus TCP/IP.

.3 WARRANTY

- .3.1 The supplier/manufacturer of the above specified equipment shall guarantee for twenty four (24) months from equipment startup or thirty (30) months from date of shipment, whichever occurs first, that the equipment shall be free from defects in design, workmanship or materials.
- .3.2 In the event a component fails to perform as specified or is proven defective in service during the warranty period, the manufacturer shall promptly repair or replace the defective part at no cost.
- .3.3 The manufacturer or contractor shall furnish OSU Utilities and Energy Services and Sustainability group with an installation, operation and maintenance manual for the steam meter and all its components, in both hard copy and electronic media including a program manual for the flow computer.

.4 INSTALLATION

- .4.1 Follow manufacturer's guidelines and submit installation drawings to OSU FOD Utilities and Energy Services for review and approval prior to installation.
- .4.2 Outages to existing steam systems for meter installation must be planned and scheduled at least two weeks in advance. See outage procedure: [https://ap.osu.edu/sites/default/files/utility\\_outage\\_procedures.docx](https://ap.osu.edu/sites/default/files/utility_outage_procedures.docx)
- .4.3 The Contractor shall obtain assistance from FOD in following the manufacturer's installation specifications such as but not limited to location of the meter components, Ethernet connection, electrical connections, local disconnect, enclosure type, and all other applicable issues. Power shall be obtained from a dedicated 20 Amp circuit in the nearest local building electrical panel.
- .4.4 The pipe diameter shall be known and shall never be reduced to install the steam meter.
- .4.5 Steam meters shall be installed with the manufacturer's recommended straight run of pipe upstream and downstream of the meter.
- .4.6 Work performed without the assistance of the manufacturer's technical erection supervisor and/or OSU Utilities shall adhere to dimensional requirements, assembly methods, and installation procedures specified herein and in the manufacturer's instruction manuals and drawings.
- .4.7 The Contractor shall comply with all erection and installation methods, techniques, sequence, and procedures requested by the manufacturer's representative and/or OSU Utilities.
- .4.8 Where manufacturer's written instructions differ significantly from those proposed by the manufacturer's representative, OSU Utilities shall determine the method used.
- .4.9 The steam meter shall be aligned with the direction of the flow in a horizontal line.
- .4.10 Gaskets shall be installed in proper alignment, free of tears and wrinkles. Bolted connections shall be tightened per gasket manufacturer's torque and sequence requirements to provide a uniform tight seal to insure uniform stress over the entire gasket area.
- .4.11 All conduit and conduit connections shall be sealed connections and meet the design and installation standards applicable for the installation area.

- .4.12 Installation services shall include all conduit and wiring to provide a fully functional meter and communication wiring to the building Ethernet switch. Termination of Ethernet communication cable at the building Ethernet switch shall be by OSU.
- .4.13 Panel addressing shall be assigned by OSU Utilities.
- .4.14 All meters and ancillary equipment shall be installed in such a manner as to provide access for routine inspections, maintenance, and a means of removal.
- .4.15 The flow computer readout/display shall be located between 5 feet and 6 feet above finished floor level.
- .4.16 All meters shall be supported independent from the piping systems.
- .4.17 Structural steel supports and miscellaneous steel required for supporting and/or anchoring meters and piping furnished under this standard shall be provided and installed in accordance with Division 5.
- .4.18 All anchors and structural steel supports shall be built to template and reinforced as required for loads imposed on them.
- .4.19 Equipment and pipe internals shall be cleaned and inspected prior to placing in service.

.5 TRAINING

- .5.1 The supplier/manufacturer shall train OSU Utilities and Energy Services and Sustainability personnel to program, calibrate, operate and maintain the above-mentioned devices for at least 3 hours. Training shall be scheduled within two weeks of completion of the installation.

.6 INSPECTION AND COMMISSIONING

- .6.1 A representative of OSU Utilities will inspect the installation and performance of the steam meter for acceptance and approval before commissioning. OSU Utilities reserves the right to witness factory testing and calibration.
- .6.2 Provide for review of required closeout documentation.
- .6.3 Provide for review loop sheets with point to point wiring diagrams in AutoCAD .dwg format.
- .6.4 Document and provide for review all electrical power sources with breaker and panel numbers.
- .6.5 Provide for review all calibration data sheets.
- .6.6 Download or load programming setup parameters.
- .6.7 OSU Utilities shall fill impulse lines with distilled water, if applicable.
- .6.8 The integrity and polarity of all terminations shall be checked and verified.
- .6.9 All piping connections must pass a service test.
- .6.10 Final system checks and closeout shall be performed.
- .6.11 Steam service will not be reinstated by OSU Utilities until installation of the steam meter is inspected by OSU Utilities and found to meet the requirements of the steam meter manufacturer and these design and installation standards.

33 63 35 VALVES

PART 1 - GENERAL

.1 RELATED DOCUMENTS

- .1.1 Requirements of the following OSU Building Design Standards apply to this Section:
  - .1.1.1 Section 33 63 10 – COMMON WORK RESULTS FOR PIPING
  - .1.1.2 Section 33 63 25 – PIPING SPECIALTIES
  - .1.1.3 Section 33 63 40 – HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT
  
- .2 DESCRIPTION OF WORK
  - .2.1 The A/E shall specify that valves furnished as part of factory-fabricated equipment shall conform to the requirements of this Section unless otherwise stated.
  - .2.2 The A/E shall note that strainers and other special valves are specified in Section 33 63 25 – PIPING SPECIALTIES.
  
- .3 SUBMITTALS
  - .3.1 Shop Drawings and Product Data: The A/E shall specify that the contractor shall submit the following:
    - .3.1.1 Manufacturer's technical product data, including installation instructions, for each type of valve. Include pressure drop curve or chart for each type and size of valve.
    - .3.1.2 Submit valve schedule showing manufacturer's figure number for corresponding valve symbol used to specify valves on this specification. List all valve sizes to be supplied for each valve symbol.
    - .3.1.3 Manufacturer's assembly-type (exploded view) shop drawings for each type of valve and valve actuator indicating dimensions, weights, materials, and methods of assembly of components.
    - .3.1.4 Technical data for electric valve actuators that indicate all features specified.
    - .3.1.5 Manufacturer's technical product data indicating the service rating of each valve type. In addition, this information shall indicate the maximum hydrostatic test pressure that the valve can take when only one side of the valve is being pressurized. The indicated hydrostatic pressure shall be good for not only the structural integrity of the valve, but should also take into consideration its continued effectiveness for providing tight shut-off service as a valve without requiring any modifications or maintenance.
    - .3.1.6 List country of manufacturer, fabrication, and assembly for all valves and valve components.
    - .3.1.7 Submit ISO 9001 and Independent Test reports, if applicable, per Quality Assurance paragraph below.
  
- .4 QUALITY ASSURANCE
  - .4.1 Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.
  - .4.2 Country of Fabrication – A/E shall specify the following:

- .4.2.1 All valves and valve components not manufactured, fabricated, and/or assembled in the United States of America or Canada must be manufactured, fabricated, and/or assembled by an ISO 9001 registered corporation.
- .4.2.2 The contractor shall submit ISO 9001 registration certificates for all corporations where valves and valve components are not manufactured, fabricated, and/or assembled in the United States or Canada.
- .4.2.3 For all valves and valve components not fabricated in the United States or Canada, the contractor shall submit an independent test report for all materials to be provided.
- .4.2.4 No valves or valve components manufactured, fabricated, and/or assembled in China including Taiwan are permitted.

.5 DELIVERY, STORAGE, AND HANDLING

- .5.1 Preparation for Transport; A/E shall specify the following:
  - .5.1.1 Contractor shall ensure valves are dry and internally protected against rust and corrosion.
  - .5.1.2 Contractor shall protect valve ends against damage to threads, flange faces, and weld-end preps.
  - .5.1.3 Set valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of functional surfaces; set butterfly valves closed or slightly open; and block swing check valves in either closed or open position.
- .5.2 Storage: A/E shall specify the following:
  - .5.2.1 Contractor shall not remove valve end protectors unless necessary for inspection; then reinstall for storage.
  - .5.2.2 Contractor shall protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. Outdoor storage of valves shall not be permitted.
- .5.3 Handling: A/E shall specify that the contractor shall rig valves to avoid damage to exposed valve parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

.1 VALVE FEATURES

- .1.1 General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features as determined by the manufacturer for installation requirements. Comply with ASME B31.1.
- .1.2 Valve Design: A/E shall specify valves with outside screw and yoke (OS&Y) stems. If non-rising stem valves are needed due to operational constraints, Utilities Division shall verify the constraints, shall review the submittals of the installation, and shall approve the installation of a non-rising stem valve.

- .1.3 Pressure and Temperature Ratings: As specified according to the individual valve specifications.
- .1.4 Sizes: Same size as upstream pipe, unless otherwise indicated.
- .1.5 Operators: A/E shall specify the following special operator features:
  - .1.5.1 Handwheels fastened to valve stem, for valves other than quarter turn.
  - .1.5.2 Lever handles, on quarter-turn valves 3 inches and smaller, except for plug valves. Provide plug valves with square heads. For valves greater than 3-inch, provide gear operator with handwheel.
  - .1.5.3 Chain-wheel operators, for all valves installed 6 feet or higher above finished floor. Extend chains to an elevation of 5 feet above finished floor.
- .1.6 Extended Stems: Where insulation is indicated or specified, A/E shall specify that the contractor shall provide extended stems arranged to receive insulation.
- .1.7 By-pass and Drain Connections: Specify and design valved by-passes. The A/E shall indicate locations on the Contract Drawings. A/E shall specify and have the contractor comply with MSS SP-45 bypass and drain connections.
- .1.8 Specify neck extensions and right angle drives where indicated and where required for access to the operator.
- .1.9 Hot Tap Valves: The A/E shall design for hot taps into existing mains that will remain energized up to the piping system design pressure where a hot tap is shown and designed for in the Contract Drawings. This procedure is also known as wet tapping. For these instances, specify that the valve shall be a full port valve to satisfy the requirements of the hot tap machine and provide a true area pipe tap, and shall satisfy the requirements of the specification of the valve group. All hot taps shall be approved by OSU Utilities.
- .2 VALVE IDENTIFICATION SYSTEM DESCRIPTION
  - .2.1 General: The A/E shall establish a system which identifies the specific valves for each piping system being designed in the Contract Drawings. The specific valve specification is linked by the service number as depicted in the "Valve Index" listed in this Section.
  - .2.2 Valves shall be identified on the Contract Drawings by symbol. Size is indicated by the upstream size.
  - .2.3 Valves are specified in this Section according to the "Valve Index". In general, the following is a description of the format:
    - .2.3.1 The first symbol, consisting of one or more numerals, indicates the valve group specification that applies to this valve.
    - .2.3.2 The second symbol, consisting of one or more letters, indicates the type of valve in accordance with the following listing:
      - GB = Globe Valve
      - BF = Butterfly Valve
      - BL = Ball Valve
      - CK = Check Valve
      - GT = Gate Valve



- AG = Angle-Stop Globe Valve
- .2.3.3 The third symbol consists of two numerals. The first numeral indicates the size group; the second numeral, when it is zero, indicates that the valve is standard type. Where the second numeral is greater than zero, it indicates modifications as described in the valve specifications herein.
- .2.3.4 The fifth symbol, consisting of a letter, indicates the type of connection to the valve as follows:
  - F = Flanged Ends
  - S = Screwed Ends
  - W = Weld Ends, Butt, or Socket
- .2.3.5 For example: For a 10-inch high pressure steam (HPS) shutoff valve, refer to 3BF21W which indicates a valve of Valve Group 3, Butterfly Type, Non-Standard, and with butt weld ends. Refer to Section 33 63 35.3 - VALVE GROUP 3 for the specification of this valve.
  
- .2.4 Note to the A/E: There may be some instances where it is desirable to substitute an item, such as a valve or gasket at a particular location, in place of the one specified in the groups listed in the Index. In that event, the item shall be clearly indicated and specified on the Contract Drawings, and such an indication is to take precedence over the item specified in the valve group specifications. All other terms of that group specification are to be observed.
  
- .3 VALVE INDEX: THE FOLLOWING PAGES CONTAIN THE "VALVE INDEX"
- .3.1 CONDENSATE, HIGH PRESSURE (Valve Group 3)
  - .3.1.1 Abbreviation: HPR
  - .3.1.2 Description: From HPS to PC System
  - .3.1.3 Maximum Design Conditions:
    - Pressure: 200 PSIG
    - Temperature: 600°F
  - .3.1.4 Normal Operating Conditions:
    - Pressure: 185 PSIG
    - Temperature: 585°F
  - .3.1.5 2 Inches and Smaller:
    - Shutoff: 3GT15W
    - Throttling: None
    - Check: 3CK11W
  
- .3.2 CONDENSATE, PUMPED (Valve Group 10)
  - .3.2.1 Abbreviation: PCR
  - .3.2.2 Description: Returned Condensate from Campus and Manhole Pumps to Plant
  - .3.2.3 Maximum Design Conditions:
    - Pressure: 200 PSIG
    - Temperature: 388°F
  - .3.2.4 Normal Operating Conditions:
    - Pressure: 50 PSIG

- Temperature: 180°F
- .3.2.5 Inches and Smaller:
  - Shutoff: 10GT11W
  - Throttling: None
  - Check: 10CK10W
- .3.2.6 2-1/2 Inches and Larger:
  - Shutoff: 10GT20F
  - Throttling: None
  - Check: 10CK20F
- .3.3 STEAM, HIGH PRESSURE (Valve Group 3)
  - .3.3.1 Abbreviation: HPS
  - .3.3.2 Description: HPS Campus Distribution
  - .3.3.3 Maximum Design Conditions:
    - Pressure: 200 PSIG
    - Temperature: 600°F
  - .3.3.4 Normal Operating Conditions:
    - Pressure: 185 PSIG
    - Temperature: 585°F
  - .3.3.5 Inches and Smaller:
    - Shutoff: 3GT10W
    - Throttling (Warm-up By-pass Service): 3AG10W
    - Check: None
  - .3.3.6 2-1/2 Inches and Larger:
    - Shutoff: 3GT20W
    - Throttling: None
    - Check: None
- .3.4 CHILLED WATER, CHILLED WATER SUPPLY & RETURN (Valve Group 2)
  - .3.4.1 Abbreviation: CWS, CWR
  - .3.4.2 Description: CWS and CWR
  - .3.4.3 Maximum Design Conditions:
    - Pressure: 100 PSIG
    - Temperature: 140°F
  - .3.4.4 Normal Operating Conditions:
    - Pressure: 100 PSIG
    - Temperature: 42°F
  - .3.4.5 2" and Smaller:
    - Shutoff: 2BL12S
    - Check: 2CK11S
  - .3.4.6 2-1/2" and Larger:
    - Shutoff: 2BF23F
    - Check: 2CK20F

.4 CHAINWHEELS

- .4.1 Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - .4.1.1 Babbitt Steam Specialty Co
  - .4.1.2 Roto Hammer Industries
  - .4.1.3 Trumbull Industries
- .4.2 Description: Lockable valve actuation assembly with sprocket rim, brackets, and chain.
  - .4.2.1 Brackets: Type, number, size, and fasteners required to mount actuator on valve.
  - .4.2.2 Attachment: For connection to butterfly valve stems.
  - .4.2.3 Sprocket Rim with Chain Guides: Ductile or cast iron, of type and size required for valve. Include zinc coating.
  - .4.2.4 Chain: Hot-dip, galvanized steel, Brass, or Stainless steel, of size required to fit sprocket rim.

### PART 3 - EXECUTION

- .1 EXAMINATION – The A/E shall specify in the contract documents the following items as they relate to Examination:
  - .1.1 Examine valve interior through the end ports for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks used to prevent disc movement during shipping and handling.
  - .1.2 Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the shipping position.
  - .1.3 Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.
  - .1.4 Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage. In cases where higher rated raised face steel flanges are mated to lower rated flat face cast iron flanges, remove raised face from steel flange before bolting together.
  - .1.5 Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.
- .2 VALVE INSTALLATIONS – The A/E shall specify in the contract documents the following items as they relate to Valve Installations:
  - .2.1 General Application: The contractor shall refer to the Contract Drawings and piping system specification sections for specific valve applications and arrangements.
  - .2.2 Locate valves for easy access and provide separate support where necessary.
  - .2.3 Contractor shall install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

- .2.4 The A/E shall design, and the contractor shall install a three-valve bypass around each control valve and throttling valve. Required locations shall be located on the Contract Drawings.
- .2.5 The A/E shall design so that the stems of valves in horizontal lines shall be pointed up (vertical). If this is not practical, the stem may be pointed in a horizontal position with prior approval from the A/E and OSU Utilities. Valves shall not be installed with stems pointed down. All valves shall have a readily accessible location. The Contractor shall be responsible to determine valve stem locations on field-routed piping prior to fabrication of the piping. When welding valves to piping, the Contractor shall insure that the valves are in the open position and shall take extreme care not to overheat and damage the seat area. All valves shall be installed in accordance with the manufacturer's instruction manual. Any valves damaged during installation shall be replaced with new, identical valves at the Contractor's expense.
- .2.6 The Contractor shall install valves in a position to allow full stem movement.
- .2.7 Installation of Swing Check Valves: Install for proper direction of flow and in horizontal position or vertical position with flow direction upwards, and with hinge pin level.
- .2.8 Insulation: Where insulation is indicated for the service, insulation of valves shall be in accordance with Section 33 63 55 – PIPING INSULATION. Where required, the contractor shall provide valves with extended stems, arranged in manner to receive insulation.
  
- .3 FLANGED CONNECTIONS – The A/E shall specify in the contract documents the following items as they relate to Flanged Connections:
  - .3.1 The contractor shall align flange surfaces parallel and level.
  - .3.2 The contractor shall assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads including anti-seize compound on bolts. Anti-seize compound shall be rated for temperatures to 600°F. Tighten bolts gradually and uniformly with a torque wrench.
  - .3.3 In cases where higher-rated steel raised face flanges mate to lower-rated cast iron flat face flanges, the contractor shall remove the raised face from the steel flange before bolting together.
  - .3.4 A/E shall specify gaskets according to the piping system and as specified in Section 33 63 45 - GASKETS.
  
- .4 ADJUSTING, CLEANING, PAINTING AND IDENTIFICATION
  - .4.1 Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, the A/E, OSU Utilities, and the contractor shall inspect each valve for possible leaks. Specify that the contractor shall adjust or replace packing to stop leaks. Specify that if a valve continues to leak that it shall be replaced.
  - .4.2 Cleaning: Specify that the contractor shall clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

33 63 35.2 VALVE GROUP 2: CHILLED WATER SUPPLY AND RETURN

.1 ANGLE VALVES  
Not Used

.2 GATE VALVES  
Not Used

.3 GLOBE VALVES  
Not Used

.4 CHECK VALVES

.4.1 SYMBOL: 2CK11S - 2 Inches and Smaller:

.4.1.1 Type: Horizontal swing check valve, screwed cover

.4.1.2 Class: 150 pound or greater screwed end

.4.1.3 Body and cover: ASTM B61 or B62

.4.1.4 Disc: Bronze

.4.1.5 Seat: Bronze

.4.1.6 API 594 Trim: 15

.4.1.7 Standard: MSS SP-80

.4.2 SYMBOL: 2CK20F - 2-1/2 Inches and Larger:

.4.2.1 Type: Horizontal swing check valve, bolted cover

.4.2.2 Class: ANSI 150 flanged.

.4.2.3 Body and cover: ASTM A216, Grade WCB or ASTM A105

.4.2.4 Disc: 13 CR

.4.2.5 Seat: 13 CR

.4.2.6 API 594 Trim: 1

.4.2.7 Standard: ANSI B16.34

.5 BALL VALVES

.5.1 SYMBOL: 2BL12S – 2 Inches and Smaller:

.5.1.1 Type: Lever operated ball valve

.5.1.2 Class: 275 pound WOG or greater screwed end

.5.1.3 Body: ASTM B61 or B62

.5.1.4 Ball: Bronze

.5.1.5 Seat: Replaceable Teflon

.5.1.6 Standard: MSS SP-80

.6 BUTTERFLY VALVES

.6.1 SYMBOL: 2BF23F – 2-1/2 Inches and Larger:

.6.1.1 Type: Single flange high performance butterfly valve suitable for bidirectional dead-end service at rated pressure without use of downstream flange

.6.1.2 Class: ANSI 150 lug type flanged.

.6.1.3 Body: ASTM A216, Grade WCB or ASTM A105

.6.1.4 Disc: 316 Stainless Steel

.6.1.5 Seat: Reinforced R-PTFE

.6.1.6 Shaft: Stainless Steel (X4CrNiMo 16-5); offset from seat plane

- .6.1.7 Shaft seal: Graphite
- .6.1.8 Standard: MSS SP-68
- .6.1.9 Actuator: Gear operator with highly visible position indicator, memory stop and lockable hand wheel

33 63 35.3 VALVE GROUP 3: HIGH PRESSURE STEAM

.1 ANGLE VALVES

.1.1 Symbol: 3AG10W – 2 Inches and Smaller:

- .1.1.1 Type: Globe style valve with a "Y" style or 45-degree angle body, designed for high steam pressure drop application for by-pass service. Valve shall be in-line repairable.
- .1.1.2 Class: 600 pound or greater socket weld
- .1.1.3 Body and bonnet: ASTM A216, Grade WCB or ASTM A105
- .1.1.4 Disc: HF Stellite
- .1.1.5 Seat: HF Stellite
- .1.1.6 API 600 Trim: 5
- .1.1.7 Shaft: Stainless steel
- .1.1.8 Packing: Graphite
- .1.1.9 Standard: ANSI B16.34

.2 GATE VALVES

.2.1 Symbol: 3GT10W - 2 Inches and Smaller:

- .2.1.1 Type: Full port gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, solid wedge disc
- .2.1.2 Class: 600 pound or greater socket weld
- .2.1.3 Body and bonnet: ASTM A216, Grade WCB or ASTM A105
- .2.1.4 Disc: HF Stellite
- .2.1.5 Seat: HF Stellite
- .2.1.6 API 600 Trim: 5
- .2.1.7 Shaft: Stainless steel
- .2.1.8 Packing: Graphite
- .2.1.9 Standard: ANSI B16.34

.2.2 Symbol 3GT15W – 2 Inches and Smaller:

- .2.2.1 Type: Full port gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, solid wedge disc
- .2.2.2 Class: 600 pound or greater socket weld
- .2.2.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
- .2.2.4 Disc: 13 CR or HF stellite
- .2.2.5 Seat: HF Stellite
- .2.2.6 API 600 Trim: 8
- .2.2.7 Shaft: Stainless steel
- .2.2.8 Packing: Graphite
- .2.2.9 Standard: ANSI B16.34

.2.3 Symbol 3GT20W - 2-1/2 Inches and Larger:

- .2.3.1 Type: Gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, flexible or solid wedge disc
  - .2.3.2 Class: 300 pound or greater butt weld
  - .2.3.3 Body and bonnet: ASTM A216, Grade WCB or ASTM A105
  - .2.3.4 Disc: HF Stellite
  - .2.3.5 Seat: HF Stellite
  - .2.3.6 API 600 Trim: 5
  - .2.3.7 Shaft: 13 CR
  - .2.3.8 Packing: Graphite
  - .2.3.9 Standard: ANSI B16.34
  - .2.3.10 Actuator: Where noted on the contract drawings, provide an enclosed gear operator
- .3 GLOBE VALVES  
Not Used
- .4 CHECK VALVES
- .4.1 Symbol: 3CK11W - 2 Inches and Smaller:
    - .4.1.1 Type: Vertical lift check valve, bolted cover
    - .4.1.2 Class: 600 pound or greater socket weld
    - .4.1.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
    - .4.1.4 Disc: 13 CR or HF Stellite
    - .4.1.5 Seat: HF Stellite
    - .4.1.6 Trim: 8
    - .4.1.7 Standard: ANSI B16.34
- .5 BALL VALVES
- .5.1 Symbol: 3BL15W - 2 Inches and Smaller:
    - .5.1.1 Type: Ball valve, designed shut-off service, in-line repairable, top-entry. Valve shall have capability of being welded into line without disassembly. Configuration shall be regular port. Operation of the valve shall automatically wipe the ball clean. The valve shall be blow-out proof, and shall be fully-guided to reduce side thrust effect. Tightness rate shall be per ASME Class V at 200 PSIG at 600°F. Valve shall be Velan "Securaseal" Type T or approved equivalent.
    - .5.1.1 Class: 600 pound socket weld ends
    - .5.1.2 Body and bonnet: 316 stainless steel, Grade CF8M
    - .5.1.3 Ball: 316SS/HC
    - .5.1.4 Seat: 316SS/Stellite
    - .5.1.5 Packing and back-up seal: Graphite
    - .5.1.6 Stem: Stainless steel
- .6 BUTTERFLY VALVES
- .6.1 Symbol 3BF21W - 2-1/2 Inches and Larger:
    - .6.1.1 Type: High performance butterfly style, rotary valve, suitable for bidirectional dead-end service at rated pressure without the use of

downstream flange. The disk movement relative to the shaft rotation shall be triple offset design. Valve shall be Adams MAK-6 or approved equivalent.

- .6.1.2 Class: 600 pound, butt weld ends
- .6.1.3 Body: Carbon steel body conforming to ASTM A216, Type WCB. The hardened bearing with bearing seal shall be retained in the body.
- .6.1.4 Disc: Retainer screws, disk, and plate shall be stainless steel.
- .6.1.5 Seat: Stellite or similar hard-surfaced metal. Seats shall be resilient, non-flexing laminate metal seal composite of stainless steel and graphite retained such that centering movement is permitted.
- .6.1.6 Shaft: Blow-out proof, 17-4 PH stainless, and single piece construction
- .6.1.7 Shaft Seal: Graphite with multiple-stud packing gland followers for adjustability utilizing Belleville style washers
- .6.1.8 Standard: API 607
- .6.1.9 Actuator: Position indicator for sizes 2-1/2 through 24 inches. Provide right angle gear operator with 2-inch AWWA nut, with loose steel hand wheel or chain wheel attachment for remote "tee" handle operation as shown on drawings. Valve actuator shall be provided with self-locking gears. Provide stem housing to allow for minimum of 5 inches of insulation.

33 63 35.10 VALVE GROUP 10: CONDENSATE RETURN

.1 GATE VALVES

.1.1 Symbol: 10GT11W - 2 Inches and Smaller:

- .1.1.1 Type: Gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, solid wedge disc
- .1.1.2 Class: 600 pound or greater socket weld
- .1.1.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
- .1.1.4 Disc: 13 CR or HF Stellite
- .1.1.5 Seat: HF Stellite
- .1.1.6 API 600 Trim: 8
- .1.1.7 Shaft: Stainless steel
- .1.1.8 Packing: Graphite
- .1.1.9 Standard: ANSI B16.34

.1.2 Symbol 10GT20F - 2-1/2 Inches and Larger:

- .1.2.1 Type: Gate valve, vertical bolted bonnet, outside screw and yoke, rising stem, flexible or solid wedge disc
- .1.2.2 Class: ANSI 300 flanged
- .1.2.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
- .1.2.4 Disc: HF Stellite
- .1.2.5 Seat: HF Stellite
- .1.2.6 API 600 Trim: 5
- .1.2.7 Shaft: 13 CR



- .1.2.8 Packing: Graphite
- .1.2.9 Standard: ANSI B16.34
- .1.2.10 Actuator: Where noted on the contract drawings, provide an enclosed gear operator.

.2 CHECK VALVES

.2.1 Symbol: 10CK10W - 2 Inches and Smaller:

- .2.1.1 Type: Horizontal swing check valve, bolted cover. Vertical check valves are to be used only upon approval of OSU Utilities and must be lift check type.
- .2.1.2 Class: 600 pound or greater socket weld
- .2.1.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
- .2.1.4 Disc: 13 CR or HF Stellite
- .2.1.5 Seat: 13 CR or HF Stellite
- .2.1.6 API 594 Trim: 1
- .2.1.7 Standard: ANSI B16.34

.2.2 Symbol: 10CK20F - 2-1/2 Inches and Larger:

- .2.2.1 Type: Horizontal swing check valve, bolted cover. Vertical check valves are to be used only upon approval of OSU Utilities and must be lift check type.
- .2.2.2 Class: ANSI 300 flanged
- .2.2.3 Body and bonnet: ASTM A351/A744, Grade CF3M Type 316L or ASTM A182, Grade F316L
- .2.2.4 Disc: 13 CR or HF Stellite
- .2.2.5 Seat: 13 CR or HF Stellite
- .2.2.6 API 594 Trim: 1
- .2.2.7 Standard: ANSI B16.34

.3 BALL VALVES

.3.1 Symbol: 10BL11W – 2 Inches and Smaller:

- .3.1.1 Type: Rated for steam service at 200 PSIG, 600°F conditions; two-piece construction, with stainless steel body, regular port, 316 SS ball and stem, replaceable seats and seals rated for temperature, blowout proof stem, vinyl-covered steel handle, socket weld ends and extended stem for insulated piping. Packing shall be graphite.

.4 BUTTERFLY VALVES

Not Used

33 63 40 HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

.1 RELATED DOCUMENTS

- .1.1 Contract Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

- .1.2 Requirements of the following Division 33 Sections apply to this Section for the installation package only:
  - .1.2.1 Section 33 63 05 – GENERAL PIPING PROVISIONS
  - .1.2.2 Section 33 63 10 – COMMON WORK RESULTS FOR PIPING
  - .1.2.3 Section 33 63 25 – PIPING SPECIALTIES
  - .1.2.4 Section 33 63 35 – VALVES
  - .1.2.5 Section 33 63 55 – PIPING INSULATION
  
- .2 DESCRIPTION OF WORK
  - .2.1 This Section provides the specification for the installation of owner furnished pre-insulated supports and is included in the pre-purchase specification package for reference only. Additionally, this Section provides the specification for providing all non-insulated pipe hangers and supports. Only the pre-insulated supports for steam and condensate are being pre-purchased by OSU. The Contractor shall provide all other anchors and supports necessary for a fully functional system. This includes all ASME B31.1 piping systems. The A/E has performed an ASME B31.1 thermal stress analysis on the high pressure steam and pumped condensate piping systems for this project. The Contractor shall provide the pipe supports, hangers and anchors as detailed in the Contract Drawings and shall provide all supports for these systems to satisfy ASME B31.1 requirements of supporting the weight of the piping systems and to accommodate lateral and axial travel in the piping system associated with thermal pipe expansion and contraction. For all other piping systems, the Contractor shall design and provide pipe support systems to satisfy ASME B31.1 code requirements for all design conditions such as dead loads (weight of pipe, insulation, etc.), thermal loads (due to thermal expansion), and other loads (earthquake, etc.).
  - .2.2 The Contractor shall design and provide an engineered pipe hanger system for all pipe systems of this project as specified in this Section.
  - .2.3 This Section provides the specification for the following components:
    - .2.3.1 Horizontal-piping hangers and supports
    - .2.3.2 Vertical-piping clamps
    - .2.3.3 Hanger-rod attachments
    - .2.3.4 Saddles and shields
    - .2.3.5 Miscellaneous materials
    - .2.3.6 Pipe alignment guides
    - .2.3.7 Pipe slides and rollers
    - .2.3.8 Anchors
  - .2.4 Supports and anchors furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division 33 Sections.
  
- .3 SUBMITTALS
  - .3.1 Shop Drawings, Product Data, and Quality Assurance Submittals: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:

- .3.1.1 Pipe hanger and support schedule for the pipe systems, including isometric drawings of the piping system. Schedule shall list all pipe supports.
  - .3.1.2 Product data, including installation instructions for each type of hanger and support component. This information shall consist of copies of the manufacturer's catalog data for the items provided in the pipe hanger assembly drawings and shall indicate dimensions, materials of construction, maximum recommended load if applicable, any operating instructions, approximate weight, and MSS SP-69 approval. Together with the pipe system isometric drawings and the manufacturer's catalog data, the assembly of the complete system should be clearly identifiable.
  - .3.1.3 Shop drawings of hangers, anchors, guides and slides to include hanger, pipe slides and guides data indicating the pipe service, location in the piping system, size, lateral and axial travel and vertical and lateral forces.
  - .3.1.4 Product data for high temperature sealant.
- .4 QUALITY ASSURANCE
- .4.1 For all pipe support related welding performed on site, qualify welding processes and welding operators in accordance with AWS D1.1 and ASME Boiler Pressure Vessel Code Section IX. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.
  - .4.2 MSS Standard Compliance
    - .4.2.1 Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.
    - .4.2.2 Select and apply pipe hangers and supports, complying with MSS SP-69.
    - .4.2.3 Fabricate and install pipe hangers and supports, complying with MSS SP-89.
    - .4.2.4 Terminology used in this Section is defined in MSS SP-90.
  - .4.3 All hangers and supports shall comply with seismic design requirements seismic requirements are stated on the drawings and are not stated in this specification. You must get the drawings to conform to this specification.
- .5 DELIVERY, STORAGE, AND HANDLING
- .5.1 Packaging, marking, shipping, receiving, and storage shall be performed per the recommendations of Paragraph 9 of MSS SP-89.
- .6 APPLICABLE PUBLICATIONS
- .6.1 The publications listed below form a part of this Specification to the extent referenced. The publications are referenced in the text by basic designation only.
  - .6.2 American Society of Mechanical Engineers (ASME)
    - .6.2.1 B31.1 Power Piping Code

- .6.2.2 BPVC Boiler Pressure Vessel Code
- .6.2.3 BPVC Section IX Welding and Brazing Qualifications
- .6.3 American Society for Testing and Materials (ASTM)
  - .6.3.1 ASTM A36 Carbon Structural Steel
  - .6.3.2 ASTM C150 Portland Cement
  - .6.3.3 ASTM C404 Aggregates for Masonry Grout
- .6.4 American Welding Society (AWS)
  - .6.4.1 AWS D1.1 Structural Welding Code - Steel
- .6.5 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
  - .6.5.1 SP-58 Pipe Hangers and Supports - Materials, Design, and Manufacturer
  - .6.5.2 SP-69 Pipe Hangers and Supports - Selection and Application
  - .6.5.3 SP-89 Pipe Hangers and Supports - Fabrication and Installation Practices
  - .6.5.4 SP-90 Guidelines on Terminology for Pipe Hangers and Supports

## PART 2 - PRODUCTS

### .1 GENERAL

- .1.1 The Contractor shall provide all necessary pipe slides, pipe guides, hangers, beam clamps, hanger rods, turnbuckles, bracing, rolls, plates, brackets, saddles, and other accessories necessary to support the pipes from the trench structures. Drilling, welding, cutting, and other operations required to attach the piping to such structures shall be part of the Contract. Channels, angles, beams, and other structural steel items indicated and necessary to attach or brace pipe supports to the structure and used solely for that purpose shall be furnished by the Contractor and the cost thereof included in the Contract.
- .1.2 All pipe lines shall be provided with complete hanger and support assemblies. Included but not limited to shall be the pipe hanger, load-bearing insulation inserts, saddles, shields, hardware, washers, nuts, turnbuckles, rods, strap, clip angles, beam clamps, through bolts, ceiling plates and grout. Pipe hangers for all pipe lines shall comply with MSS SP-58, SP-69, and SP-89.
- .1.3 Pipe lines to be supported include all new piping and tubing, existing piping that requires temporary supporting due to structural related work, and existing piping where required due to new piping connecting to existing piping.

### .2 HANGER DESIGN SERVICES

- .2.1 The A/E has provided a pipe support design for the high pressure steam and pumped condensate piping as described in .2 - DESCRIPTION OF WORK Section .2.1. The Contractor shall design an engineered pipe hanger system for all other pipe systems of this Contract. A detailed analysis is not required to be submitted, however, the Contractor shall perform calculations to the detail necessary to demonstrate that the pipe support system is adequate for the service. For all pipe hangers, supports, anchors, guides, etc., the Contractor shall submit pipe system isometric drawings. Provide proposed equipment manufacturer, manufacturer's model number and size,

- construction, finish, quantities and/or lengths. Indicate pipe group, line size, insulation thickness.
- .2.2 The Contractor shall provide engineering and design services and submit calculations and analysis for any deviation or modification to the pipe support systems designed by the A/E.
  - .2.3 The design conditions utilized to generate the hanger system design shall be taken from the piping system specification in Section 33 63 10 – COMMON WORK RESULTS FOR PIPING.
  - .2.4 Piping Connecting to Existing Systems
    - .2.4.1 The Contractor shall be responsible for verifying that existing supports are acceptable where tie-ins to existing piping occur. The Contractor shall consider all additional material required as part of this Contract.
    - .2.4.2 In order to perform calculations of the movement and support of the piping systems, it is recognized that the Contractor will have to identify existing piping and supports not currently shown on the Contract Drawings.
- .3 GENERAL DESIGN GUIDELINES
- .3.1 All supports and parts shall conform to the latest requirements of the ASME Code for Pressure Piping B31.1, and MSS SP-58, MSS SP-69, and MSS SP-89, except as supplemented or modified by the requirements of this Section.
  - .3.2 Designs generally accepted as exemplifying good engineering practice, using stock or production parts, shall be utilized wherever possible.
  - .3.3 Weight balance calculations shall be made to determine the required supporting force at each hanger location and the pipe weight load at each equipment connection.
  - .3.4 Pipe hangers shall be capable of supporting the pipe in all conditions of operation. They shall allow free expansion and contraction while providing continuous support of the piping and prevent excessive stress resulting from transferred weight or force being introduced into the pipe or connected specialties and equipment.
  - .3.5 Hanger Rods and Supports
    - .3.5.1 All rigid rod hangers shall provide a means of vertical adjustment after erection.
    - .3.5.2 Hanger rods shall be subject to tensile loading only. At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit swing.
    - .3.5.3 Where horizontal piping movements are such that hanger rod angularity is greater than or equal to 4 degrees from the cold to hot position of the pipe, the hanger pipe and structural attachments shall be designed and positioned in such manner that the rod is vertical in the hot and cold position.
    - .3.5.4 Hanger components shall not be used for purposes other than for which they were designed. They shall not be used for rigging and erection purposes.

- .3.6 Pipe Anchors, Guides and Bracing Requirements
  - .3.6.1 All pipe anchors and guides shall be of welded steel construction designed with a safety factor of not less than five.
  - .3.6.2 The Contract Drawings for this project indicate the location of all anticipated anchors, guides, and braces required to control excessive forces and moments on equipment, over stressing of pipe material, and/or extreme mal-positioning and misalignment of supports or expansion joints caused by thermal expansion and contraction.
  - .3.6.3 The Contractor shall recognize the necessity and provide anchors, guides, and sway braces to prevent extreme mal-positioning and misalignment pipe supports, over stressing of pipe, and/or excessive forces and moments on equipment caused by hydraulic surge in the lines associated with normal operation and hydrostatic testing. These anchors, guides, and braces are not indicated on the Contract Drawings; the Contractor shall anticipate that such are necessary and shall allow for same in his contract; the Contractor shall also provide these items as necessary in the design of pipe support systems for piping systems included in the Contractor's scope of piping systems support designs.
  - .3.6.4 After flushing and startup of all pipe lines, each shall be observed to locate excessive movement and then shall be guided or anchored by the Contractor at this time.
  - .3.6.5 Where the piping system is subject to shock loads, such as seismic disturbances or thrusts imposed by the actuation of safety valves or hydrostatic testing hanger design shall include provisions for rigid restraints or shock absorbing devices of approved design, such as Anvil Fig. 200 or approved equal shock and sway suppressor.
  - .3.6.6 Supports, guides, and anchors shall be so designed that excessive heat will not be transmitted to the supporting steel. The temperature of supporting parts shall be based on a temperature gradient of 100°F per inch distance from the outside surface of the pipe.
- .3.7 Thin-wall Stainless Steel Lines: Ceiling hung thin-wall stainless steel pipes shall be supported by pre-insulated clamp type hangers and rollers with a stainless steel bearing plate or shield secured in place between the hanger or roller and the pipe. The bearing plate or shield shall be a minimum 12-inches long, cover a minimum of 1/2 of the pipe circumference, and be made 1/8-inch thick stainless steel bent to fit the pipe insulation The maximum spacing of pipe hangers on thin wall stainless steel lines shall be no more than:
  - .3.7.1 1/2 inch through 1-1/4 inch = 8 feet
  - .3.7.2 1-1/2 inch through 4 inch = 10 feet
  - .3.7.3 5 inch and larger = 12 feet
- .3.8 Finishes: All hangers and support assemblies, associated accessories and hardware shall have factory galvanized finish.

- .4 HORIZONTAL-PIPING HANGERS AND SUPPORTS
  - .4.1 Hangers shall be so spaced as to prevent sag and permit proper drainage. Hanger spacing shall be in accordance with MSS SP-69 except where indicated on the drawing and specified herein. Provide a hanger at elbows (within 2 feet) and terminations.
  - .4.2 Horizontal pipe attachments shall be selected in accordance with Table 1 of MSS SP-69. Selection of components must strictly adhere to the allowable temperature ranges listed and the presence of insulation.
  - .4.3 Pipe Clamps: Double-bolt pipe clamps when used on insulated pipe shall match the insulated pipe outer diameter. High density insulation inserts matching the pipe insulation shall be provided.
  - .4.4 Clevis Hangers
    - .4.4.1 Clevis hangers used on uninsulated lines shall match the pipe outer diameter. Clevis hangers used on insulated pipes shall be so sized that the inner diameter of the hanger matches the outer diameter of the piping insulation.
  - .4.5 Brackets used for supporting piping shall be of welded steel construction with a design safety factor of not less than five.
- .5 PIPING AND SUPPORTS, ROUTING AND LOCATION
  - .5.1 Piping and conduits shall be run parallel with the lines of the structure, unless otherwise shown or noted on the Contract Drawings. The different service pipes, valves, and fittings shall be so installed that after the covering is applied there will not be less than one inch clear space between the finished covering and other work and between the finished coverings of parallel adjacent pipes. Hangers and supports on different service lines, running parallel with each other and parallel to the lines of the structure. Where conflicts between the trades result, they shall be resolved by the Contractor to the A/E's satisfaction and at no expense to the University.
- .6 VERTICAL-PIPING CLAMPS
  - .6.1 Provide Factory-fabricated vertical-piping clamps complying with MSS SP-58 selected by Contractor to suit vertical piping systems in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper-piping systems.
- .7 HANGER-ROD ATTACHMENTS
  - .7.1 Provide factory-fabricated hanger-rod attachments complying with MSS SP-58 as indicated on the drawings to suit pipe hangers and structure attachments in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each pipe support application. Select size of hanger-rod attachments to suit hanger rods and pipe support load. Provide copper-plated hanger-rod attachments for copper-piping systems.

- .8 STRUCTURE ATTACHMENTS
  - .8.1 Provide factory-fabricated structure attachments complying with MSS SP-58 as indicated on the drawings to suit substrate conditions in accordance with MSS SP-69 and manufacturer's published product information. Provide copper-plated building attachments for copper-piping systems.
  
- .9 SADDLES AND SHIELDS
  - .9.1 As required for the pipe support load and the load bearing capacity of the insulation. Comply with MS SP 58 and MSS SP-69 type 40.
  
- .10 MISCELLANEOUS MATERIALS
  - .10.1 Steel Plates, Shapes and Bars: Provide products complying with ASTM A 36.
  - .10.2 Cement Grout: Portland Cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration. Refer to Section 33 63 05 – GENERAL PIPING PROVISIONS. Pipe anchors shall utilize a high temperature rated grout mix.
  - .10.3 Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.
  
- .11 PIPE SLIDES AND GUIDES
  - .11.1 Pipe Slides and Guides: The A/E shall specify that the Contractor shall review carefully the insulation type, materials, and movements and submittal requirements in order to meet the design intent. Specify that units shall be rated for temperature for each service – steam and condensate to 600°F, pumped equipment drain to 212°F and chilled water to 120°F. Specify that all steel clamps and steel shapes components shall be ASTM A36 hot-dipped galvanized. Slide pads shall be graphite rated to 2000 PSI with a 0.1 coefficient of friction, bonded and secured to backing plates with recessed set screws. Hardware shall be ASTM A307 or B7 plated bolts, studs, and nuts. Structural insulation inserts shall be high density/high compressive strength Marinite P. Insulation shall be calcium silicate with moisture repellent on steam and condensate pipe services in buildings, tunnels and manholes and shall be high density/high compressive strength Cellular Glass on steam and condensate pipe services in trenches. (A/E refer to Section 33 63 55 – PIPING INSULATION for insulation thickness). Specify and design that the pipe slides and guides shall be selected for the anticipated lateral and axial travel and vertical and lateral forces at each pipe support location. Specify and design that the pipe slides and guides shall be designed and constructed in accordance with ASME B31.1 and MSS-SP 58 and have a design safety factor of 5.
  - .11.2 Identification: Specify that the Contractor shall, for each support and base plate, clearly identify with the pipe support designation. Each support and base plate shall have markings that identify the axial and lateral positions of



the support in the cold position. This must be installed and coordinated in the field with the A/E's thermal stress analysis and design documents.

.12 HARDWARE FOR PRE-INSULATED SUPPORTS

12.1 The contractor shall provide the levering nut, expansion anchor, expansion anchor nut, washer, and grout pad for each support.

.13 HIGH TEMPERATURE SEALANT

13.1 Provide high temperature, one part, silicone rubber sealant. Sealant shall be rated to 500°F for continuous operation. Basis of design: Tremco Trempro 644.

PART 3 - EXECUTION

.1 GENERAL

.1.1 Specifications of this part apply to the execution of contractor provided and owner furnished supports.

.2 RECEIPT OF PRE-PURCHASED SUPPORTS

.2.1 Contractor shall remove pre-purchased supports from the delivery vehicle on or near the jobsite.

.3 INSPECTION

.3.1 The installation, adjustment, and inspection of all hangers systems shall be performed by the Contractor in accordance with Paragraph 10 of MSS SP-89.

.3.2 During renovation and installation of equipment, the Contractor shall be responsible for the temporary support of all piping systems where necessary due to the phasing of construction. Temporary support systems shall be in accordance with the requirements of this Section.

.4 PREPARATION

.4.1 Proceed with installation of permanent hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors and other building structural attachments.

.4.2 Prior to installation of hangers, supports, anchors and associated work but after the pipe hanger submittal has been reviewed by the A/E, the Installer shall meet at project site with Contractor, installer of each component of associated work, installers of other work requiring coordination with work of this Section, and A/E for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with this Section.

.5 INSTALLATION OF HANGERS AND SUPPORTS

.5.1 General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69 and SP-89. Install supports with maximum spacing complying with MSS SP-69 and to permit

- normal pitch of pipe with deflection and bending stress maintained at a minimum.
- .5.2 During the hydrostatic testing of any line with spring hangers designed for fluids lighter than water, travel stops or locks must be installed on the hangers or temporary solid rod supports must be provided during the entire time the line is filled with water to support its additional weight and thereby prevent overloading the springs. When tests are completed, the stops, locks, or solid rods must be removed and the hanger springs set for their cold loads.
  - .5.3 On the first occasion that any line is brought to operating temperature, the Contractor shall immediately reset each spring hanger to its hot load position and lock the adjusting nut or screw.
  - .5.4 Install building attachments to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping.
  - .5.5 Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.
  - .5.6 Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.
  - .5.7 Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
  - .5.8 Seal the connection between each pre-insulated support and the adjoining insulation with high temperature silicone sealant.
- .6 INSTALLATION OF ANCHORS
- .6.1 Install anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.1 and to prevent transfer of loading and stresses to connected equipment.
  - .6.2 Fabricate and install anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.1 and with AWS Standards D1.1.
- .7 METAL FABRICATION
- .7.1 Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.
  - .7.2 Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
  - .7.3 Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:
    - .7.3.1 Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

- .7.3.2 Obtain fusion without undercut or overlap.
- .7.3.3 Remove welding flux immediately.
- .7.3.4 Finish welds at exposed connections so that no roughness shows after finishing and so that contours welded surfaces to match adjacent contours.

.8 ADJUSTING

- .8.1 Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve proper slope of pipe.
- .8.2 Touch-Up and Cleaning: Clean and touch-up all field welds, bolted connections, and abraded areas of the shop finish on all support components with cold galvanizing repair.
- .8.3 Refer to Section 33 63 05 – GENERAL PIPING PROVISIONS.

33 63 45 GASKETS

PART 1 - GENERAL

.1 RELATED DOCUMENTS

- .1.1 Contract Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- .1.2 Requirements of the following Specification Sections apply to this Section:
  - .1.2.1 Section 33 63 05 – GENERAL PIPING PROVISIONS
  - .1.2.2 Section 33 63 10 – COMMON WORK RESULTS FOR PIPING
  - .1.2.3 All related specific piping specification Sections.

.2 DESCRIPTION OF WORK

- .2.1 The extent and type of gaskets required by this Section shall be as indicated on the Contract Drawings and/or specified in other Division 48 Electrical Sections.

.3 SUBMITTALS

- .3.1 Product Data: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
  - .3.1.1 Manufacturer's technical product data, including materials of construction, thickness, pressure and temperature rating, manufacturer's model number, and storage requirements.

.4 DELIVERY AND STORAGE

- .4.1 Transport, Storage, and Handling:
  - .4.1.1 Keep gaskets in dry area protected from weather.
  - .4.1.2 Do not prepare gaskets until ready for installation.
  - .4.1.3 Do not reuse gaskets.

PART 2 - PRODUCTS

- .1 Gasket Identification System: a system has been established which identifies the specific gasket for each service identified in the contract drawings. The specific

gasket group is linked by the service number as listed in the "Piping, Gasket, and Service Group Index", which appears in Section 33 63 10 – COMMON WORK RESULTS FOR PIPING. An example is also presented in that section.

.2 GASKET GROUPS

.2.1 Gasket Group HP: Gaskets shall be spirally wound, Type 304 stainless steel with non-asbestos filler material and carbon steel outer ring. Gaskets shall be 1/16-inch thick and conform to the flange face on which they are used. Acceptable products from acceptable manufacturers include: Flexitallic Style CG with Flexicarb filler and 316L winding, manufactured by Flexitallic Inc., or approved equivalent.

.2.2 Gasket Group HPB: Gaskets shall be spirally wound, Type 316L stainless steel with non-asbestos filler material and carbon steel outer ring. Gaskets shall be 1/8 inch thick and conform to the flange face on which they are used. Acceptable products from acceptable manufacturers include: Flexitallic Style CG with Flexite Super filler, manufactured by Flexitallic Inc., or approved equivalent.

PART 3 - EXECUTION

.3 INSTALLATION

.3.1 Match flanges within piping system and at connections with valves and equipment where specified.

.3.2 Clean flange faces and install gaskets.

.3.3 Tighten bolts to provide uniform compression of gaskets.

33 63 50 IDENTIFICATION FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

.1 RELATED DOCUMENTS

.1.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

.2 DESCRIPTION OF WORK

.2.1 Piping identification shall be provided for all new work in accordance with the requirements of this Specification Section.

.2.2 Types of identification devices specified in this Section include the following:

2.2.1 Pipe Contents and Identification Markers

2.2.2 Equipment Identification

2.2.3 Brass Valve Tags

.2.3 Piping identification furnished as part of factory-fabricated equipment is specified as part of equipment assembly in other Division 33 Sections.

.3 SUBMITTALS

.3.1 Product Data and Samples: In accordance with Section 01 33 00 - SUBMITTAL PROCEDURES, submit the following:

- .3.1.1 Manufacturers' technical product data and installation instructions for each type of identification device specified; Include a list of all piping systems indicating a proposed nomenclature.
    - .3.1.2 Samples of each color, lettering style, and other graphic representation required for Pipe contents and identification markers.
- .4 QUALITY ASSURANCE
  - .4.1 Codes and Standards:
    - .4.1.1 ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.
- .5 SEQUENCING AND SCHEDULING
  - .5.1 Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
  - .5.2 Install identifying devices before installing concealment.

PART 2 - PRODUCTS

- .1 PIPING IDENTIFICATION MATERIALS
  - .1.1 General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division 33 Sections. For each identification type, provide all tags from same manufacturer with same text, style, color, shape, and other identification features.
- .2 PIPE CONTENTS AND IDENTIFICATION MARKERS
  - .2.1 Description: The Contractor shall provide pipe markers or painted stenciled identification on all pipe systems as described below. Pipe markers and stencils shall indicate line contents, direction of flow, and that insulation is asbestos free. Line contents shall match service. Obtain approval from A/E for identification of each service.
  - .2.2 Material: Fade-resistant, non-ferrous metal material. Snap-on or strap-on type. All markers shall have a minimum service temperature of -40°F to 175°F and be rated for outdoor service.
  - .2.3 Arrangement: For external diameters (including insulation) equal to or greater than 3 inch, provide stencils. For external diameters (including insulation) equal to or greater than 1-1/2 inch and less than 3 inches, rectangular pipe contents indication marker shall contain only one line of text and appear on both sides of the pipe with a flow direction arrow roll wrapping 360 degrees around at both ends of the pipe contents indication marker. For external diameters less than 1-1/2 inch, provide full-band marker extending 360 degrees around pipe. The working of each marker shall be spelled out in the direction of the travel of the pipe.
  - .2.4 Colors: For steam, condensate, and other related systems, stencil shall be orange letters and arrows. "Asbestos Free" stencils shall have a blue background with white letters. See Part 3 – EXECUTION, Sections .3 and .4 for painting considerations.
  - .2.5 Text Height: Content minimum text height shall be as follows:

Overall OD Including Insulation	Min. Letter Size
3/4 to 1-1/4 inch	1/2 inch
1-1/2 to 2 inches	3/4 inch
2-1/2 to 6 inches	1-1/4 inches
8 to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

.3 EQUIPMENT IDENTIFICATION

.3.1 All equipment shall have a manufacturer's data tag. When this tag has been removed, painted over, or rendered illegible, the Contractor shall provide new tags. Tags shall be brass plates on which operational data plus information regarding areas or other equipment served is stamped. Permanently attach tags to the equipment in locations where they can easily be read.

.4 BRASS IDENTIFICATION TAGS

- .4.1 Description: For the purpose of identifying valves. Provide on each valve a brass identification tag. OSU shall provide a schedule of valve tags to the Contractor.
- .4.2 Lettering: Symbol letters and numerals shall be not less than 1/2 inch high, shall be deeply impressed into the metal tag, and shall be Black filled.
- .4.3 Size and Shape: Rectangular, minimum 1-1/2 inch high by 1-1/2 inch wide by 0.040 inch thick.
- .4.4 Fastening: For valves, attach through punched hole on side of tag to valve body or yoke, not the valve handwheel, with Monel wire.

PART 3 - EXECUTION

.1 GENERAL INSTALLATION REQUIREMENTS

.1.1 Coordination: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, install identification after completion of covering and painting. In addition, provide pipe markers only after each line has been complete, erected, purged, tested, and/or painted.

.2 PIPE SYSTEM IDENTIFICATION

.2.1 General: Provide pipe markers on every system including pipe contents and flow direction. Provide "Asbestos Free" insulation markers for all pipe that is insulated under this contract. Locations of all markers shall be subject to final approval by the A/E.

.2.2 Location:

2.2.1 Location: Locate pipe markers in a conspicuous manner at a minimum of every 40 feet as follows:

- Upstream and downstream each isolation valve, control valve and pressure regulating station
- Near each valve station and control device
- Near each branch or change of direction
- On both sides where pipe passes through walls, floors, or ceilings within 4 feet of the barrier

- Near major equipment origination and termination points
- Near the inside and outside of concealed points
- In each Manhole and Valve Vault
- At elevation changes

2.2.2 Where pipes run parallel to each other, identify each pipe in the same general location.

.3 PAINTING COLOR SCHEME

.3.1 All piping systems shall receive an aluminum jacket so no paint is required for piping insulation systems.

.4 ADJUSTING AND CLEANING

.4.1 Painting and Insulating: Do not paint or insulate over any identification tags. Tags shall be installed after all painting is completed or shall be covered during painting.

33 63 55 PIPING INSULATION

PART 1 - GENERAL

.1 RELATED DOCUMENTS:

.1.1 Contract Drawings and General Provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections apply to this Section.

.1.2 Requirements of the following Specification Sections apply to this Section:

.1.2.1 Section 33 63 10 – COMMON WORK RESULTS FOR PIPING

.1.2.2 Section 33 63 25 – PIPING SPECIALTIES

.1.2.3 Section 33 63 35 – VALVES

.1.2.4 Section 33 63 40 – HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

.1.2.5 Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT

.2 DESCRIPTION OF WORK

.2.1 Scope: Extent of the piping system and equipment required to be insulated by this Section is indicated in this Section, on the Contract Drawings, and other Division 33 Sections.

.2.2 Types: Types of piping insulation systems specified in this Section include the following:

2.2.1 Pipe insulation

2.2.2 Equipment insulation

2.2.3 Insulation jackets

2.2.4 Insulation accessories

.3 QUALITY ASSURANCE

.3.1 Codes and Standards: Provide insulation conforming to the following standards:

.3.1.1 American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM standards, including:

- ASTM B 209 Aluminum Alloys
- ASTM C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
- ASTM C 195 Mineral Fiber Thermal Insulating Cement
- ASTM C 196 Expanded or Exfoliated Vermiculite Thermal Insulating Cement
- ASTM C 302 Test Method for Density of Preformed Pipe Covering-Type Thermal Insulation
- ASTM C 335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation
- ASTM C 356 Test Method for Linear Shrinkage of Preformed High Temperature Thermal Insulation Subjected to Soaking Heat
- ASTM C 411 Test Method for Hot Surface Performance of High Temperature Thermal Insulation
- ASTM C 449 Mineral Fiber Hydraulic - Setting Thermal Insulating and Finishing Cement
- ASTM C 534 Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
- ASTM C 547 Mineral Fiber Preformed Pipe Insulation
- ASTM C 553 Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
- ASTM C 612 Mineral fiber Block and Board Thermal Insulation
- ASTM C 795 Thermal Insulation for Use in Contact with Austenitic Stainless Steel
- ASTM C 921 Practice for Determining Properties of Jacketing Materials for Thermal Insulation
- ASTM D 579 Greige Woven Glass Fabrics
- ASTM E 84 Test Method for Surface Burning Characteristics of Building Materials
- ASTM C591 Pre-Formed Polyurethane Pipe Insulation

.3.1.2 National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:

- NFPA 25 Test Methods, Surface Burning Characteristics of Building Materials.

.3.1.3 Underwriter's Laboratory Inc.

- UL 723 Tests for Surface Burning Characteristics of Building Materials.



- .3.2 Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity, where applicable.
  - .3.3 Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame spread index specified herein, and smoke developed index specified herein, as tested by ASTM E 84 (NFPA 255) method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove that fire hazard ratings for materials proposed for use do not exceed those specified.
  - .3.4 The work shall be done only by mechanics thoroughly experienced in pipe insulation, and the quality of workmanship shall be the best attainable.
- .4 SUBMITTALS
- .4.1 Shop Drawings, Product Data, and Samples: In accordance with Section 01 33 00 – SUBMITTAL PROCEDURES, submit the following:
    - .4.1.1 Manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K value, flame spread and smoke developed ratings, thickness, and furnished accessories for each mechanical system requiring insulation. Furnish necessary test data certified by an independent testing laboratory. Provide manufacturer's certification that insulation or any other materials provided shall not accelerate stress corrosion of stainless steel pipe per ASTM C795.
    - .4.1.2 Submit manufacturer's sample of each piping insulation type required, and of each duct and equipment insulation type required. Affix label to sample completely describing product.
    - .4.1.3 Insulation application schedule indicating equipment or piping systems sizes, insulation material, thickness, insulation vapor barriers, jackets, types of insulated fittings, accessories, and methods for each insulated system.
- .5 DELIVERY, STORAGE, AND HANDLING
- .5.1 Delivery: Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.
  - .5.2 Storage and Handling: Protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.
  - .5.3 Outside storage of insulating materials is prohibited.
  - .5.4 Insulating materials and accessory materials shall be packed in shipping containers so constructed as to ensure safe delivery of the materials in a satisfactory condition. The shipping containers shall be legibly marked with the name of the manufacturer, material, size, type, thickness, density, and quality contained in each container.

- .5.5 The Contractor shall provide a storage area for weather protection of all insulation materials and accessory materials after their arrival at the job site.
- .5.6 Installed insulation which has not been weather-proofed shall be protected from inclement weather by approved waterproof sheeting installed by the Contractor. Any wet or damaged insulation shall be removed and replaced by the Contractor at no additional cost.

**PART 2 - PRODUCTS**

**.1 INSULATION GENERAL REQUIREMENTS**

- .1.1 General: Provide insulation conforming to the referenced publications and the specified temperature ranges and approved manufacturers products.

**.2 INSULATION IDENTIFICATION SYSTEM**

- .2.1 A system has been established which identifies the specific insulation type, insulation thickness, and insulation finish for each service indicated in the Contract Drawings. The specific insulation type, insulation thickness, and insulation finish is linked by the service number as listed in the "Piping Insulation Service Group Index" which appears in this Section. In addition, the insulation group only is listed in the "Piping, Gasket, Insulation, and Service Group Index" in Section 33 63 10 – COMMON WORK RESULTS FOR PIPING. See that Section for an example.
- .2.2 Where insulation is scheduled for a pipe system below, insulation is required regardless of whether or not the letter designation for the insulation group is specifically called out on the pipe line description in the Contract Drawings. In some cases, a different amount of Insulation may be required for a piping line than what is specified in the indexes. In these cases, the required insulation group will be changed and called out on the pipeline description on the Contract Drawings and its corresponding thickness shall prevail.

**.3 PIPING INSULATION SERVICE GROUP INDEX:**

- .3.1 PIPING INSULATION SERVICE GROUP INDEX – FOR PIPING LOCATED IN TRENCHES AND STEAM AND CONDENSATE MANHOLES

SERVICE	LINE DESCRIPTION	INSULATION GROUP	INSULATION FINISH	SERVICE GROUP ON DWGS
EQUIPMENT	50 PSIG at 212°F Max.	N/A	N/A	PED
DRAIN, PUMPED	Sump Pump Discharge in Trenches			
CONDENSATE, HIGH PRESSURE	200 PSIG at 600°F Max., from HPS to PC System	E	AA	HPR
CONDENSATE, PUMPED	200 PSIG at 388°F Max., Returned Condensate from Campus and Manhole Pumps to Plant	C	AA	PCR

DIVISION 33 – UTILITIES

STEAM, HIGH PRESSURE	200 PSIG at 600°F Max., HPS Campus Distribution	E	AA	HPS
----------------------	---	---	----	-----

.3.2 PIPING INSULATION SERVICE GROUP INDEX – FOR PIPING LOCATED IN TUNNELS AND VAULTS

SERVICE	LINE DESCRIPTION	INSULATION GROUP	INSULATION FINISH	SERVICE GROUP ON DWGS
EQUIPMENT DRAIN, PUMPED	50 PSIG at 212°F Max., from Sump Pump Discharge in Trenches	N/A	N/A	PED
CONDENSATE, HIGH PRESSURE	200 PSIG at 600°F Max., from HPS to PC System	J	CC	HPR
CONDENSATE, PUMPED	200 PSIG at 388°F Max., Returned Condensate from Campus and Manhole Pumps to Plant	H	CC	PCR
STEAM, HIGH PRESSURE	200 PSIG at 600°F Max., HPS Campus Distribution	J	CC	HPS
CHILLED WATER	150 PSIG at 140°F Max., CWS & CWR Campus Distribution	A	AA	CWS & CWR

.4 INSULATION THICKNESS SCHEDULE: Nominal insulation thickness shall be as follows:

Insulation Group	A	B	C	D	E
<b>PIPE TEMPERATURE (°F)</b>					
<b>Pipe Size</b>	<b>32 to 199</b>	<b>200 to 299</b>	<b>300 to 399</b>	<b>400 to 500</b>	<b>500 to 600</b>
1/2"	1	1-1/2	1-1/2	1-1/2	2
3/4"	1	1-1/2	1-1/2	1-1/2	2
1"	1	1-1/2	2	2	2
1-1/4"	1	1-1/2	2	2	2
1-1/2"	1	1-1/2	2	2	2
2"	1	1-1/2	2-1/2	2-1/2	2-1/2
2-1/2"	1	1-1/2	2-1/2	2-1/2	2-1/2
3"	1-1/2	1-1/2	2-1/2	2-1/2	2-1/2
4"	1-1/2	1-1/2	3	3	3
6"	2	3	3	3	3
8"	2	3	3	3	4
10"	2	3	3-1/2	3-1/2	5
12"	2	3	3-1/2	3-1/2	5
14"	2	4	3-1/2	3-1/2	6

16"	2	4	3-1/2	3-1/2	6
-----	---	---	-------	-------	---

Note: Insulation thicknesses listed are nominal thickness in inches.

.5 PIPE INSULATION GROUP SPECIFICATIONS

.5.1 General: Provide pipe insulation as specified below as dictated by the "Piping Insulation Service Group Index". Provide removable/reusable blankets in accordance with Insulation Group "R".

.5.2 Groups "A" Through "E" - Pipe Insulation:

.5.2.1 Insulation shall be 100 percent rigid cellular glass, totally inorganic, with no binder. Absorption of moisture shall be 0.2% or less per ASTM C240. Water-vapor permeability shall be 0 perm-in per ASTM E96. Average compressive strength shall be 90 psi ASTM C165. Average density shall be 7.5 lb per cubic foot per ASTM C303. Maximum service temperature shall be 900°F. Thermal conductivity shall be no greater than 0.29 Btu-in/hr-Ft<sup>2</sup> - °F at mean temperature of 75°F per ASTM C177 and C518. The insulation shall conform to ASTM E84 (5 Flame, 0 Smoke). Linear expansion shall be 3 inches per 100 linear feet at 600°F. Insulation shall be fabricated in half sections wherever possible. For large diameter piping where half sections are not practical, curved side wall segments are preferred. Provide double layer system with staggered joints for all systems where pipe temperature is listed as 400°F or greater.

.5.2.2 Fittings and valves shall be insulated with the same insulation system and built-up to the same thickness as the insulation for the adjoining pipe in accordance with insulation manufacturer's instructions.

.5.2.3 Provide insulation from one of the following manufacturers and product trade names:

<b>Manufacturer</b>	<b>Trade Name of Approved Product</b>
Pittsburgh Corning	FOAMGLAS

.5.2.4 Provide insulation with thickness as specified in Paragraph "Insulation Thickness Schedule".

.5.2.5 Pipe surfaces shall be clean and dry prior to insulating. Insulation may be temporarily held in place with stainless steel wire or fiber reinforced tape overlapped a minimum of 6 inches prior to the insulation finish being installed. The tape and/or wire may remain on the insulation beneath the insulation finish.

.5.2.6 The finish shall be as designated in "Piping Insulation Service Group Index" and specified in this Section.

.5.3 Insulation from inorganic silicate (calcium or sodium) or expanded perlite specifications can be referenced in BDS 40 07 00. Division 40 of the OSU BDS has not been published, therefore, the project A/E shall contact OSU Utilities' project lead for specific insulation details.

- .5.4 Pipe Insulation from glass fiber specifications can be referenced in BDS 40 07 00. Division 40 of the OSU BDS has not been published, therefore, the project A/E shall contact OSU Utilities' project lead for specific insulation details.
- .5.5 Group "P" – Pipe Insulation:
  - .5.5.1 Pipe insulation on steam and condensate may be this type where pipes are close together which may present interference with the standard specified insulation type and thicknesses. Insulation thicknesses may not be reduced where potential interferences exist and therefore this insulation thickness must be considered. Potential interferences are called out on the drawings. If other potential interferences exist, notify the University and the Engineer for approval prior to using this insulation system.
  - .5.5.2 Insulation shall be Aspen Aerogels, Inc. Pyrogel XT with minimum 11 lb/ft density with k value of 0.26 Btu-in/hr – ft<sup>2</sup> – °F at a mean temperature of 330°F. Thickness shall be 2" for 16" HPS, 1 1/2" for 12" HPS, 1" for 10" HPS, 3/4" for 8" PCR, 1/2" for 6" and 4" PCR.
  - .5.5.3 Fittings and valves shall be insulated with same insulation and built up to the same thickness.
  - .5.5.4 Provide an aluminum jacket with aluminum bands as specified for other systems in this section.
- .5.6 Group "R" – Removable/Reusable Insulation
  - .5.6.1 Insulating material shall be tailor-made removable/reusable blankets. The blankets shall be made with a high temperature fiberglass mat without the use of chemical binders and suitable for temperatures up to 1200°F.
- .6 PIPE INSULATION FINISH SPECIFICATIONS
  - .6.1 General: Provide pipe insulation finish as specified below and where stated in the "Piping Insulation Service Group Index".
  - .6.2 Group "AA" - Insulation Finish
    - .6.2.1 Steam, High Pressure Condensate, and Pumped Condensate Piping: Provide PITT WRAP jacketing system suitable for 200°F that requires heat fused seal.
    - .6.2.2 Provide an aluminum jacket over the PITT WRAP as specified below.
      - .6.2.2.1 Apply directly over the insulation an aluminum weatherproof jacket. This jacket shall be manufactured from aluminum alloy 5005 or 3003 half hard, not less than 0.016-inch thick, fabricated with 3/16-inch corrugations running lengthwise of pipeline. The aluminum shall be factory attached to a moisture barrier of kraft paper treated for this service.
      - .6.2.2.2 All joints shall be made rain or drip proof. Longitudinal joints shall be located on the side of the pipe with the open edge of the lap turned down to shed water. Circumferential joints on pipes that do not have enough slope to get a good shingle effect to keep water out of the joint shall have the

inside end of the lap beaded or sealed with a permanently elastic mastic type sealant designed for this service.

- .6.2.2.3 The aluminum jacket shall be secured by aluminum straps 1/2-inch wide by 0.020-inch thick. The straps shall be placed on 12-inch centers (maximum). Each circumferential joint shall have a strap at the midpoint of the lap.
- .6.2.2.4 On long radius bends, the aluminum jacket shall be in sections cut on the miter, overlapped, and forming a neat snug fit, using sufficient bands and fasteners to hold jacket properly in place.
- .6.2.2.5 All 30-inch diameter and smaller insulated elbows shall be protected with a prefabricated elbow jacket. The jacket shall be manufactured of high purity 0.024-inch aluminum with a suitable moisture barrier on the interior of the jacket to prevent decomposition of the aluminum. The prefabricated elbow jacket shall be applied directly over the insulated fitting.
- .6.2.2.6 All insulation on fittings, flanges, valves, and other irregular shaped items on which the aluminum jacket cannot be neatly applied shall be finished as follows:
  - Over the smooth insulation surface and cloth reinforcing as described below, apply the mastic in two or more coats at a sufficient rate to provide a dry film thickness of 1/8 inch.
  - The mastic shall be applied by trowel or spray. The exact application conditions, procedures and recoat time shall be as recommended by the mastic manufacturer.
  - Reinforcing shall consist of a No. 10 mesh nylon or Dynel cloth. Flat surfaces shall be secured to the insulated structure on 18-inch centers maximum.
  - The mastic shall be gray or metallic gray vinyl VI-CRYL, CP-10 or CP-11 manufactured by Childers Products Company, or WC-1 manufactured by Vimasco Corporation.
  - Upon completion of the work, the Contractor shall furnish the A/E a certificate stating that the mastic has been applied in the same manner as specified or approved by its manufacturer.

.6.3 Group "CC" - Insulation Finish

- .6.3.1 Insulation jacket shall be weatherproof aluminum. The jacket shall be manufactured from aluminum alloy 5005 or 3003 half hard, not less than 0.016-inch thick, fabricated with 3/16-inch corrugations running lengthwise of pipeline. The aluminum shall be factory attached to a moisture barrier of kraft paper treated for this service.
- .6.3.2 All joints shall be made rain or drip proof. Longitudinal joints shall be located on the side of the pipe with the open edge of the lap turned down to shed water. Circumferential joints on pipes that do not have enough slope to get a good shingle effect to keep water

out of the joint shall have the inside end of the lap beaded or sealed with a permanently elastic mastic type sealant designed for this service.

- .6.3.3 The aluminum jacket shall be secured by aluminum straps 1/2 inch-wide by 0.020-inch thick. The straps shall be placed on 12-inch centers (maximum). Each circumferential joint shall have a strap at the midpoint of the lap.
- .6.3.4 Provide mastic for all insulation on fittings, flanges, valves, and other irregular shaped items on which the aluminum jacket cannot be neatly applied.

### PART 3 - EXECUTION

#### .1 GENERAL INSULATION INSTALLATION

- .1.1 General: Install insulation material with smooth and even surfaces. Unless otherwise specified, install insulation materials, accessories, and finishes in accordance with the manufacturer's published recommendations.
- .1.2 Fire Precaution: Care shall be exercised by the Contractor that no cutting, welding, or open flames are permitted in the areas where flammable mastics or other materials are used. The precaution period shall extend until the material has cured sufficiently so that no further fire hazard exists.
- .1.3 Insulation Release: Before insulation is applied to any piping or equipment, the Contractor shall obtain from the Engineers a written release stating that the item is ready for insulation.
- .1.4 Manufacturer's Recommendations: All materials specified herein shall be installed in full accordance with the manufacturer's recommendations for the best performance and durability of his product, notwithstanding any requirements or omissions herein with respect to preparation of equipment before insulating or method of application.
- .1.5 Expansion Joints in Insulation: Where necessary, the Contractor shall furnish suitable expansion joints in the insulation to prevent cracking or wrinkling due to expansion and contraction of the surface being insulated.
- .1.6 Surface Condition: Do not apply insulation materials until all surfaces to be covered are clean and dry, all foreign materials, such as rust, scale, and dirt have been removed, and surfaces have been painted. Insulation shall be clean and dry when installed and during the application of any finish.
- .1.7 Moisture and Vapor Seal: Provide a complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors and other projections through insulation on cold surfaces for which a vapor seal is specified.
- .1.8 Asbestos Containing Material:
  - .1.8.1 No Contractor, Subcontractor, or Supplier shall furnish any asbestos containing material.
  - .1.8.2 Provide "Asbestos Free" identification labels for insulated piping and equipment as specified in Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.

.2 INSULATION FOR PIPING

.2.1 General: Installation

.2.1.1 All sectional pipe insulation shall be applied with staggered girth joints tightly butted together as recommended by the insulation manufacturer. Each section of insulation is to be held in place with separate loops of 16 gauge annealed stainless steel wire placed not more than 12 inches on center.

.2.1.2 Insulation shall not be applied to any flanged, machined, or welded surfaces until they have passed all field tests, including hydrostatic, and have been released for insulation.

.2.2 Insulation of Valves, Flanges, Fittings, Etc.

.2.2.1 High maintenance items such as control valves, some flanged valves, flanged joints, strainers and similar type items located in insulated lines shall be insulated with removable/reusable blankets. The Contractor shall insulate all high maintenance items as directed by the A/E with removable/reusable blankets in accordance with Insulation Group "R" of this Section.

.2.2.2 In all insulated lines, with the exception of the high maintenance items which are insulated with blankets, the valve bodies, fittings, and flanges shall be insulated with the same material and the same thickness as the pipe insulation using mitered pipe insulation and/or block insulation securely cemented together. All flange insulation shall be the removable type, but not the replaceable type.

.2.3 Gaps and Terminations: Neatly terminate all insulation at each end of unions and at other points where required and seal. Fill gaps occurring at hangers with insulating cement and finish flush with the adjoining pipe insulation as specified for fittings.

.2.4 Butt pipe insulation against pipe hanger insulation inserts. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3 inch wide vapor barrier tape or band.

.3 PAINTING AND IDENTIFICATION

.3.1 Aluminum jackets shall not be painted. Paint all glass canvas jacket insulated surfaces Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.

.3.2 Provide identification labels and tags for all piping systems and equipment as specified in Section 33 63 50 – IDENTIFICATION FOR PIPING AND EQUIPMENT.

.3.3 Do not insulate or paint over factory attached nameplate labels on equipment, valves, and other devices.

**33 70 00. ELECTRICAL UTILITIES METERING**

PART 1 GENERAL

.1 APPLICATIONS:

.1.1 The objective of this design standard is to outline the requirements of electric meters.



- .1.1.1 The permanent building meters in buildings on the Columbus campus utilized by The Ohio State University shall communicate this consumption to a local display and to the campus-wide Energy Metering & Monitoring system (InStep eDNA server). The electric meter shall include the instantaneous kilowatt rate.
- .1.1.2 A meter with system display is required for each Main and Distribution feeder circuit. The metering device and its display may be mounted on the Feeder Breaker or its associated Metering compartment. Additional duplicate metering shall be displayed on the Substation main control boards associated with the Main Transformers and their MV transformer Secondary feeders and report its information back to the campus distribution monitoring system, (ION Enterprise).
- .1.2 The electric meter, elements and devices shall meet custody transfer measurement requirements. Custody transfer measurement furnishes quantity and quality information which can be used as the basis for a change in ownership and/or a change in responsibility for materials, e.g., billing for rate of energy demand plus totalized energy transfer.
- .1.3 All Primary System Meters, potential and current transformers shall be of utility acceptable quality and accuracy, and shall be considered the property of OSU Utilities, within Facilities Operations and Development once placed in service. An engraved name plate displaying potential transformer primary and secondary voltage ratings and current transformer primary and secondary current ratings shall be installed below the meter.
- .1.4 If complete meter setup cannot be done from the front panel, any required software, cables, and keys shall be provided to OSU Utilities, within Facilities Operations and Development.
- .1.5 As a standard feature on all secondary metering, with the exception of temporary construction meters, a 4-pole GE PK-2 panel-mounted test block and 4 pole current test plug shall be installed flush on switchgear for portable test metering connection and use by OSU Utilities personnel. Current transformer poles shall have shorting auxiliary contacts and all CT wiring shall be on shorting type terminal blocks. (See Figure 5 for typical connection diagram).
- .1.6 If the meter used for kWh reading does not have a meter serial number on the front of the display, then an engraved name plate shall be installed below the meter displaying the meter serial number.

## PART 2 PRODUCTS

- .1 Distribution Metering – Revenue
  - .1.1 Feeder/Distribution metering serves the dual purpose of providing instantaneous values of feeder operating conditions and provides trending , logging and historical data for planning and operations use over a secure OSU Utilities data acquisition network.
    - .1.1.1 The monitor shall provide the following information:
    - .1.1.2 Voltage (kiloVolts) - phase to neutral and phase to phase ABC

- .1.1.3 Current (kiloAmps)- line and neutral (residual) ABCN
  - .1.1.4 Kilowatts (kW)
  - .1.1.5 Kilo-vars (kVAR)
  - .1.1.6 Kilo-voltamperes (kVA)
  - .1.1.7 Voltage maximum and averages over 15 min intervals
  - .1.1.8 Current Maximum and averages over 15 min intervals
  - .1.1.9 Kilowatt maximum demand based on 15 minute intervals
  - .1.1.10 Kilo-voltampere maximum demand based on 15 minute intervals
  - .1.1.11 Power Factor
  - .1.1.12 Transient waveform capture
  - .1.1.13 Power Quality measurements, logging and trending
- .1.2 Permanent Building/System Metering – Revenue
- .1.2.1 The monitor shall provide the following information:
    - .1.2.1.1 Voltage – phase to neutral and phase to ABC
    - .1.2.1.2 Amps – present reading and 15 minute maximum demand ABCN
    - .1.2.1.3 Kilowatt-hours
    - .1.2.1.4 Kilowatt maximum demand base on 15 minute intervals
    - .1.2.1.5 Power Factor, Kilo VAR, Kilo VAR Hour, KVA
  - .1.2.2 Avoid metering schemes that are only capable of measuring partial loads connected to the distribution system or electrical apparatus being monitored. Specify that a meter shall be installed to measure electrical load from the distribution system, including, but not limited to fire pumps.
  - .1.2.3 Primary Service (customer) metering shall be performed by metering installed on the low voltage side of the Primary Transformer, before or after the Secondary main feeder circuit breaker or fused disconnect.
- .1.3 Construction Metering – Revenue
- The prime construction contractor shall provide one kW-hr meter suitable to record the total electrical consumption of the construction site. The contractor is responsible for the proper connection and installation of the meter and associated sources of current and potential. OSU Utilities, within Facilities Operations and Development supports an application process that the Contractor must follow as indicated herein
- .1.3.1 Meters shall be maintained accessible to and will be read by University Personnel. Failure to place a proper functioning meter into service prior to drawing electrical load will result in electrical usage charges that are estimated by the University based on the greater of the first full month of properly metered service or an estimate by OSU Utilities, within Facilities Operations and Development of likely usage based on worst case connected load for the period, whichever is greater. OSU Utilities, within Facilities Operations and Development reserves the right to refuse new

electrical service to any site not metered in accordance with design standards. Dysfunctional metering installation/systems are subject to estimated billing and back charges.

.2 CERTIFICATIONS

- .2.1 All devices shall be certified to be used the way it is being applied meeting all local and governing building codes.
- .2.2 Provide “Certificate of Compliance and Calibration” for each meter, which provides test tracing back to (NIST).
- .2.3 Provide IEC 60687 Class 0.5S and ANSI 12.20 Class 0.5 accuracy.

.3 COMMUNICATIONS

.3.1 Distribution Metering

- .3.1.1 Each individual kW-hr meter specified must have communications capability. The communications shall be MODBUS RTU via a combination of serial RS-485 over 18 AWGA twisted pair and TCP/IP Ethernet over single mode fiber to medium voltage gear, to satisfy the information flow requirements to the OSU Utilities’ ION Enterprise meter data collection system. The final design configuration shall be determined by the OSU Utilities, within the Facilities Operations and Development.

.3.2 Permanent Building/System Metering

- .3.2.1 Each individual kW-hr meter specified must have communications capability. The communications shall be MODBUS RTU via a combination of serial RS-485 over 18 AWGA twisted pair and TCP/IP Ethernet over CAT6 cable to the campus-wide Energy Metering & Monitoring system (InStep eDNA server). The final design configuration shall be determined by OSU Utilities, within Facilities Operations and Development.

.4 WARRANTY TERMS

- .4.1 THE SUPPLIER/MANUFACTURER OF THE ABOVE SPECIFIED EQUIPMENT shall guarantee for twenty four (24) months from equipment startup or thirty (30) months from date of shipment, whichever occurs first, that the equipment shall be free from defects in design, workmanship or materials.
- .4.2 In the event a component fails to perform as specified or is proven defective in service during the warranty period, the contractor shall promptly repair or replace the defective part at no cost to the University.
- .4.3 The manufacturer or contractor shall furnish OSU Utilities, within Facilities Operations and Development, with an installation, operation and maintenance manual for the electric meter and all of its components.

.5 ELECTRIC METER MANUFACTURERS AND MODELS

- .5.1 Low voltage building meters

- .5.1.1 Schneider Electric, PowerLogic model ION6200 Enhanced 2 Series meter or IQ 150 meter with fused control transformer. (See Figure 5).
  - .5.1.2 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents
- .5.2 Medium voltage metering
- .5.2.1 Schneider Electric, PowerLogic model ION7600 series meter with fused control transformer or with its power supplied from the meter potential transformer fused secondary. The 125 VDC power supply is the preferred option if a reliable DC source is available. Meter shall use Ethernet over single mode fiber for communications.
  - .5.2.2 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents
- .6 SHORTING BLOCKS
- .6.1 A 4-pole GE PK-2 panel-mounted test plug.
  - .6.2 Other models and manufacturers require submittal by the A/E and approval by The Ohio State University Utilities before including in the Design Development Documents

### PART 3 EXECUTION

#### .1 INSTALLATION

- .1.1 Follow manufacturer's guidelines and submit installation drawings to OSU Utilities for review and approval prior to installation.
- .1.2 The Contractor shall give OSU Utilities 10 University working days notification by calling Service2Facilities at 614-292-HELP prior to the installation of the electric meter for assistance in following the manufacturer's installation specifications such as but not limited to location of the meter components, Ethernet connection, electrical connections, local disconnect, enclosure type, and all other applicable issues.
- .1.3 Work performed without the assistance of the manufacturer's technical erection supervisor and/or OSU Utilities shall adhere to dimensional requirements, assembly methods, and installation procedures specified herein and in the manufacturer's instruction manuals and drawings.
- .1.4 The Contractor shall comply with all erection and installation methods, techniques, sequence, and procedures requested by the manufacturer's representative and/or OSU Utilities.
- .1.5 Where manufacturer's written instructions differ significantly from those proposed by the manufacturer's representative, OSU Utilities shall determine the method used.
- .1.6 All conduit and conduit connections shall meet the design and installation standards applicable for the installation area.

- .1.7 Installation services shall include all conduit and wiring to provide a fully functional meter and communication wiring to the building Ethernet switch. Connection of Ethernet communication cable at the building Ethernet switch shall be coordinated through OSU Utilities. If necessary, Cat-6 shielded cable or single mode fiber and conduit shall be installed between the electric meter and the nearest building network switch.
  - .1.8 Panel/Meter IP and MODBUS addressing shall be assigned by OSU Utilities.
  - .1.9 MODBUS data registers shall be provided, at a minimum, for instantaneous kW rate, and totalized value.
  - .1.10 All meters and ancillary equipment shall be installed in such a manner as to provide access for routine inspections, maintenance, and a means of removal.
  - .1.11 All anchors and structural steel supports shall be built to template and reinforced as required for loads imposed on them.
  - .1.12 The height of the meter display shall be five feet (5.0') from the finished floor or 4-½ feet from the floor elevation to the center of the meter if mounted on a vertical panel or cabinet. If mounted in switchgear, the meter display should be mounted at a height that facilitates meter access and viewing.
- .2 TRAINING
- .2.1 The supplier/manufacturer shall train OSU Utilities personnel to program, calibrate, operate and maintain the above-mentioned devices for at least 3 hours. Training shall be scheduled within two weeks of completion of the installation.
- .3 INSPECTION AND COMMISSIONING
- .3.1 A representative of OSU Utilities will inspect the installation and performance of the electric meter for acceptance and approval before commissioning. OSU Utilities reserves the right to witness factory testing and calibration.
  - .3.2 Provide for review of required closeout documentation.
  - .3.3 Provide for review, of wiring schematics with point to point wiring diagrams in AutoCAD .dwg format.
  - .3.4 Document and provide for review, all electrical power sources with breaker and panel numbers.
  - .3.5 Electric meters shall be commissioned and a commissioning record document shall be issued identifying each meter by its serial number and location and confirming its correct installation and function.
  - .3.6 Electric meter commissioning shall be a joint effort between the project's Contractor, A/E and/or Commissioning Agent, and The Ohio State University. Electrical service will not be connected or reinstated by OSU Utilities until installation of the electric meter is inspected by OSU Utilities and found to meet the requirements of the electric meter manufacturer and these design and installation standards.

**33 71 00. ELECTRICAL UTILITY TRANSMISSION AND DISTRIBUTION**

**33 71 26. TRANSMISSION AND DISTRIBUTION EQUIPMENT**

**.1 MAIN SUBSTATION(S) POWER DISTRIBUTION**

- .1.1 Bulk electrical power is delivered to the University at 138,000 Volts. The University transforms this power down to 13.6 kV at the main substation(s) bus(es), which in turn then distributes it to Primary feeder pairs that traverse the campus. See Figure 1 for overall MV Distribution system layout and nomenclature. All permanent buildings, and building complexes, and construction temporary power are provided with service drops from both circuits of a feeder pair through one or more primary switches. These switches allow the buildings to be switched between primary feeders when feeders need to be de-energized for construction work, maintenance, or due to failure. Each building or building complex has one or more transformers fed from the primary switches through a variety of switch and secondary feeder arrangements designed to suit the specific needs of the buildings. See Figure 2 for typical Primary Service arrangements.
- .1.2 Primary service is generally restricted to significant 3 phase loads. The number of primary services on any given feeder pairs must be limited for reliability reasons and to insure that circuit feeders can be quickly isolated and restored after experiencing a circuit failure. Preference is given to providing primary service switches that can separately switch multiple building loads from one primary service tap.
- .1.3 Buildings are assigned a normal and an alternate feed. This assignment may be changed by UTHVS to meet the needs of the High Voltage system. The alternate feed is not a “Back-up” feed. Circuits are routinely removed from service to accommodate construction needs, maintenance and repair of cable and switches. The practice of assigning a “Regular” and “Backup” building feed is generally prohibited. Certain campus circuit pairs have designated “third feeders”. In such instances, some buildings fed from the circuit pair will have an assigned “Regular” feed and a “Backup” from the associated third feeder.
- .1.4 Some of the larger buildings or building complexes are equipped with third feeders and a set of two Primary Select switches. This design allows a “Switched Primary” feeder pair to be run throughout the building or building complex. This arrangement provides extra switching flexibility and greater failure tolerance.
- .1.5 Some Feeder pairs have a set of two Primary select switches feeding branch circuits with a switched pair of feeders. This feature is provided to reduce switching time and aid in location of system faults. See Figures 2 and 3.
- .1.6 Third Feeders have been added to the MV Distribution system to increase feeder capacity and improve system reliability and availability. See Figure 3
- .1.7 The addition of Dual Primary Select switches with switched primary pairs along with the third feeders will ultimately increase Feeder Protection selectivity and support automation of the Campus electrical distribution system while reducing the time it takes to locate, isolate and transfer campus loads in the case of feeder failure.
- .2 Columbus Campus Primary voltage: The available underground primary distribution voltage is 13.2 kV volt 3-wire, 3-phase, 60-cycle. This system is a solidly grounded Wye system.

- .3 Regional Campuses Primary voltage: While the University strives to maintain a level of consistency between regional campuses, each campus is unique. Consult the UTHVS or TSG for specifics of the power distribution systems at Regional Campuses.

33 71 49 MEDIUM VOLTAGE DISTRIBUTION SYSTEM

- .1 EXTERIOR UNDERGROUND RACEWAYS:
  - .1.1 All underground cables of any classification shall be installed in approved duct raceway systems. The number and size of conduits depend on the service classification and are designed to meet the electrical system and facility needs. See Figure 4 for typical Primary duct bank configurations.
  - .1.2 Direct burial of underground cables is prohibited.
  - .1.3 Cold bending of PVC conduits is prohibited.
  - .1.4 New raceway installations shall be designed for future capacity addition.
  - .1.5 Additional spare ducts shall be included as required by the University to afford spare ducts for failure or circuit additions. Duct banks that are intended to carry Primary circuits shall be provided with enough spare ducts to accommodate a minimum of one additional circuit pair. Duct banks intended to carry lateral building feeder taps shall be designed with a minimum of one spare duct per duct bank.
  - .1.6 Raceway ducts within duct banks for Primary cables shall be schedule 40 PVC conduit. PVC conduit shall be adapted to rigid steel conduit beginning at ten feet (10') before entrance to outside of building foundations.
  - .1.7 PVC conduit shall be adapted to rigid steel conduit beginning at ten feet (10') before entrance into manholes. This requirement may be waived with the written approval of Utilities UTHVS in specific instances where adequate structural integrity can be demonstrated and where the duct bank design uses the added reinforcement and is four or more 6" ducts high by two wide. Raceways shall be encased in concrete as Primary duct bank.
- .2 PRIMARY DUCT BANKS
  - .2.1 Raceways for primary electric shall be encased in a reinforced concrete (3" minimum cover) envelope. The standard size for primary electric ducts shall be 6 inches for Primary mains, and 5 inches for Primary building laterals and Primary load ways.
  - .2.2 Ducts for Primary mains shall be placed on 9 1/2 inch centers for 3-inch spacing between power ducts. Ducts for Primary laterals and Primary load ways shall be in duct banks with power ducts placed on 8 1/2 inch centers for 3-inch spacing between power ducts. Primary mains shall contain a minimum of six 6-inch diameter schedule 40 PVC power ducts and two concentrically located 2-inch diameter schedule 40 PVC ducts provided for ancillary use. Primary laterals and Primary load ways shall contain a minimum of four 5-inch diameter schedule 40 PVC power ducts and one concentrically located 2-inch diameter schedule 40 PVC conduit provided for ancillary use. Carlon Snap-Loc Spacers, or approved equivalent, supported on concrete or ceramic blocks shall be placed at eight (8) ft intervals. See Figure 4 for duct bank details.
  - .2.3 Ducts shall be installed below the frost line at a minimum thirty (30) inches below finished grade and shall be sloped to drain into manholes.

- .2.4 Multiple parallel duct bank installations shall observe a minimum horizontal spacing of two (2) feet of soil, thermally conductive sand or compacted 304 aggregate. This provision does not apply to duct bank crossings with an acute angle of greater than 30 degrees.
- .2.5 Two longitudinal steel reinforcing bars with a minimum of 18 inch overlap shall be used for each layer of duct in all duct banks. In instances where the duct bank crosses a roadway or high vehicle traffic area, two additional steel reinforcing bars shall be provided at the top and bottom of the bank to assist in distributing the load. Ducts shall be bundled and tie-wired to assure integrity of the duct array during pour. Concrete shall encase the duct bank installation a minimum of 3-inches on all sides. Provide one (1) #5 steel reinforcing bar for each conduit in the duct bank). Tie off the reinforcing bars to the plastic supports holding the conduit in place. Allow for a minimum of 2" of concrete over the reinforcing. Concrete envelopes shall extend through foundation and manhole walls designed so that the envelope becomes a structural member providing support for bridging the area that has been excavated and back filled for foundation or manhole walls. Encasement concrete shall be City of Columbus CMS 499 Class C, 4000 psi @ 28 days.
- .2.6 Tear tape shall be placed approximately one foot above the duct bank when being backfilled.
- .2.7 Elbows shall be long-radius rigid steel conduit.
- .2.8 End Bells shall be steel. Aluminum, plastic or pot metal end bells are prohibited. End bells on conduit entering a building or manhole shall have their broader opening mounted flush with the interior surface of the wall penetrated by the duct.
- .2.9 Duct banks of 6 or more ducts should avoid crossing an area with an unfavorable thermal environment (i.e., crossing steam pipes, parking lots) as such cable installations may require de-rating.
- .2.10 Ducts banks shall not pass within 10 feet of a buried steam line in any direction. If it becomes necessary to cross a steam line, acceptable insulation of the crossing must be provided and approved by UTHVS.
- .2.11 Primary ducts banks shall cross gas lines below the gas piping without exception.
- .2.12 Primary voltage cable within a building shall be installed in rigid steel conduit with UL approved steel pull boxes. Label conduit every 10 feet and pull boxes shall be labeled "DANGER 13,200 VOLTS".
- .2.13 Cable or conductor bending radius shall not be less than eight times the overall diameter for non-shielded cable and twelve times the diameter of shielded cable during or after installation. On systems operating above 1 kV to ground, cables installed in nonmetallic conduit shall have an effectively grounded shield, and one 4/0 single conductor 600 V insulated ground wire run with the three phase circuit in the same conduit.
- .2.14 Primary cable ducts between manholes or other terminal points shall be as straight as practical. All bends shall be "sweep" bends and any bend greater than ten (10) degrees per ten (10) foot length of duct, shall be made with rigid steel conduit. Where possible, duct banks shall be run straight from manhole



- to manhole; where bends are necessary, the total shall not exceed 90 degrees in addition to any turn up at the pad or equipment.
- .2.15 Layout: Primary duct banks shall be a maximum of two ducts wide by four ducts high. Exception may be taken on a case-by-case basis for accommodation of site specific issues and to address special circumstances of loading or for instances where duct installation is by boring or other means where a rectangular array is not practical. All requests for exception must be approved in advance of installation by OSU Utilities UTHVS
  - .2.16 For final preparation, a properly sized steel mandrel shall be pulled through all new or repaired ducts. Mandrel shall be  $\frac{1}{4}$ " to  $\frac{1}{2}$ " smaller in diameter than the duct; this shall be a test witnessed by UTHVS. Each duct shall be proved clear and usable, cleaned, have a No. 12 type TW pull wire left in place, and spare ducts shall have duct plugs installed.
  - .2.17 Color Additive: Concrete for Primary duct banks shall have a red color additive mixed in the concrete for identification. Specify Solomon 417 Apple Red; suggested mix approximately three and a half pounds (3-1/2 lbs.) per 80 pounds of cement to provide identifiable red color as warning to any one digging into the high voltage cable run. The concrete supplier shall premix concrete. Color additive shall not be hand-troweled in, and shall not be sprinkled.
  - .2.18 A member of UTHVS shall inspect and approve primary ducts before concrete is poured. A member of UTHVS shall witness the concrete pour.
  - .2.19 Excess concrete shall not be placed in the hole or used to raise the top of the duct bank greater than 3 " above the top of the ducts. Duct banks shall be a continuous pour from bottom to top. Concrete shall be poured and compacted so as to avoid inclusion of air pockets or areas where concrete doesn't completely cover ducts and reinforcements. Remove all excess concrete from University property.
  - .2.20 Soil may be used to backfill duct bank excavations provided they are not in streets or where recurrent heavy surface loadings are anticipated. High traffic and heavy load areas must be backfilled with  $\frac{3}{4}$ " crushed stone or CDF with a covering layer of compacted soil or gravel and resurfaced to original wear surface.
  - .2.21 MV electrical duct banks are not to be routed under buildings or through locations where subsurface conditions are unsuitable or where major construction is anticipated that could destabilize adjacent soils and place the duct bank and the Primary circuits contained in jeopardy.

.3 MANHOLES

- .3.1 Manholes shall not be installed inside buildings or in areas of public assembly.
- .3.2 All medium voltage manholes or vaults shall have High Voltage Line and Utility truck access. It is common practice to place vaults under Primary switches to facilitate cabling and to allow for a lower switch profile. Such vaults follow the design for manholes and are constructed with not only manhole cover access but also an opening for cable entrance directly from the vault area into the bottom of the Primary switch enclosure.

- .3.3 Manhole covers shall be round, 32-inch diameter, heavy duty, traffic rated (H20) with the word "ELECTRIC" cast in cover as applicable. Covers shall not have gaskets or be bolted down. Two slots, on opposite edges, shall be provided to permit using manhole hooks to remove cover.
- .3.4 Flame Proofing: Cables in manholes, vaults, cable spreading areas, and at conductor terminations where more than one Primary Circuit is present shall be flame proofed with tape (3M #771). Control cables and fiber optic cables shall also be flame proofed in manholes, vaults and cable spreading areas where power cables are present and can pose a threat if faulted.
- .3.5 Cables in manholes shall be tagged with phase and feeder numbers marked using 1" x 3" plastic tags with 1/2" high by 1/16" thick engraved lettering (black on white).
- .3.6 Primary Cables to the Transformers and Switches: Cables going into buildings from manholes shall be marked with the building's name for identification using plastic with engraved 1/2" high by 1/16" thick lettering (black on white).
- .3.7 Manholes shall be located and sized to allow workable pulling tension on cables and other considerations in planning. Minimum inside measurement of the medium voltage compartment shall be 6' wide by 10' long by 7' high. Maximum spacing between successive manholes shall be 400' measured along the length of the duct bank. Throat and manhole overall depth shall be limited to facilitate cable pulling activity and limit the risk of injury from falling. (48" throat and overall depth to floor from finished grade of 16')
- .3.8 Access shall not be less than a 32-inch round chimney equipped with removable steel ladder placed in each manhole.
- .3.9 Hardware shall include pulling eyes in each wall opposite of a duct bank at 3' above finished floor and the center of the floor, inserts, and cable racks. Racks shall be Underground Devices CR 36 brackets with RA 14 or RA 20 support arms Hardware to be secured by stainless steel fasteners.
- .3.10 At least one 5/8" diameter by 10' long driven copper-clad steel ground rod shall be installed in each manhole 6 inches from a wall.
- .3.11 A 1" x 1/4" copper ground bus shall be placed around the perimeter of the manhole walls 6" from the ceiling for bonding all cable shields. Connect to ground rod with 4/0 copper cable. Connect manhole reinforcing steel, duct bank reinforcing steel and manhole metal hardware with #2 copper cable. Use Cadweld® for ground connections.
- .3.12 All electrical ducts entering manhole shall be perpendicular to the manhole wall and shall be at least a minimum of ten feet (10 ft.) straight from the manhole wall. All ducts banks shall enter manhole within one foot of a corner. Do not center manhole on duct bank.
- .3.13 End bells shall have their wide end positioned flush with the interior of the manhole wall.
- .3.14 Provide a sump hole in manhole floor in area below cover. Slope floor to sump.
- .3.15 Manhole covers shall be at finished grade. The ring and cover shall be centered over chimney.
- .3.16 In applications where the duct bank employs a four or more high by two wide 6" duct design, Utilities UTHVS, as stated in previously in paragraph 33 71

49.1.6, may permit the duct bank to enter manholes without the requisite ten foot steel conduits and the use of cast steel end bells. This may be permitted in instances where the duct bank approach to the manhole is straight for ten feet or more and the intersection of the duct bank and manhole is at right angles.

.4 WIRE AND CABLE

.4.1 Copper conductors of 98 percent conductivity shall be used unless use is restricted by Government Agencies. Aluminum conductors are prohibited.

.4.2 COLOR CODING

Color coding for 13.2 kV cables and 5 kV cables shall be as follows:

Phase	Voltage 13.2 kV and 5 kV
-------	--------------------------

(Each with identifiable colored stripe)

Neutral	White or Gray
---------	---------------

A	Brown
---	-------

B	Orange
---	--------

C	Yellow
---	--------

Equipment Ground	Green, Black
------------------	--------------

.5 PRIMARY VOLTAGE CABLES (13,200 Volt)

.5.1 The insulation must be compounded and mixed by the cable manufacturer in its own facilities using a closed, clean process to ensure maximum control and continuity of quality. The strand shield and insulation shield shall be extruded, semi-conducting thermosetting material that is compatible with the insulation.

.5.2 Cable shall be suitable for normal installation in conduit and shall be suitable for continuous submersion in water. The cable shall be capable of continuous operation in both a wet or dry environments at a conductor temperature of 105°C in normal operation, 130°C in emergency overload operation, and of 250°C in short-circuit operation.

.5.3 Main feeders in the Columbus campus power system shall be a minimum of 500 kcmil 4/0 cables shall be used for the laterals and load ways from the primary circuit taps into a building for each primary selective switch pair. Some circuit pairs have associated "Third Feeders" which are designed to back up multiple feeder pairs. Where applied, these circuits shall be conductored with 750 kcmil cable from the source CB in the Main substation to its end. Laterals to individual Primary switches are 750, 500, or 4/0 depending on the individual service requirements. In instances where building services are 1500 kVA or less, individual load ways may be sized #2 AWG or the standard 4/0. Any load way less than 4/0 must be designed to accommodate a replacement 4/0 cable including the duct bank housing the conductors.

.5.4 Only cables from companies with an established reputation and an excellent track record in the medium voltage power cable manufacturing industry shall be installed in primary system applications.

.5.5 13,200-volt primary feeder and service cables shall be UL Listed and from a list of manufacturers approved by UTHVS.

- .5.5.1 One compact conductor per ASTM B496 or compressed soft-annealed copper per ASTM B-3, stranding per ASTM B-8.
  - .5.5.2 220 mil Ethylene Propylene Rubber (EPR) insulated, 15 kV, 133% rated, MV 105°C cables.
  - .5.5.3 The shields shall be uncoated 5 mil bare copper tape applied helically over the insulation with a minimum overlap of 25 percent of the tape width.
  - .5.5.4 The jacket shall be continuously extruded, 80 mil, 'low-smoke (Critical Temperature Index > 240°C) zero halogen'.
  - .5.5.5 Cable construction shall comply with the latest requirements of ICEA S-93-639/NEMA WC-74.
  - .5.5.6 Under limited circumstances and on a case by case basis, where risk to personnel and equipment is considered to be minimal, the requirement for a zero halogen jacket may be waived with Utilities (UTHVS) approval. Utilities maintains a listing of approved MV cable suppliers and approved cable jacket materials and constructions.
- .5.6 Each primary circuit shall have the power conductors arranged in a three phase array sharing a common duct. Each 3 conductor array shall include within its duct a 4/0, 600 volt insulation class ground wire bonded to all splices and terminations and grounded in substation(s) and manholes.
  - .5.7 Primary circuits comprised of multiple conductors per phase shall have the power conductors arranged in three phase arrays in multiple ducts. Each 3 conductor array shall include within its duct a 4/0, 600 volt insulation class ground wire bonded to all splices and terminations and grounded in substation(s) and manholes
  - .5.8 Phase rotation of primary service termination shall be established prior to termination. Phase positions at terminating equipment shall be Phase "A", "B", and "C" left to right facing the front, or "A", "B", and "C" front to rear. Circuit phasing shall be from the Substation to the point of splicing/termination and be performed with the assistance and under the observation of an UTHVS representative.
- .6 **SPLICING AND CABLE TERMINATIONS**
    - .6.1 All work performed on non-lead, medium voltage (1 kV to 35 kV) cables shall be performed by personnel with adequate training and experience and certified as qualified by the UTHVS. To be considered qualified for cable splicing, the individual's employer must submit a resume with past training and experience supported by documentation of their having had the appropriate formal training in the preparation of relevant medium voltage splices and terminations prior to the individual performing any work. Splicing and termination experience shall be recent (one to five years depending on extent of prior experience) and relevant to the type of splice and cables being spliced.
    - .6.2 Add label, which is applied to each phase wire where all terminations and splices occur. Every splice shall be labeled with an engraved plastic tag (black on white) containing the following information:

- Date of splicing
  - Name of company that performed splicing; this shall include both lead and non-lead splices.
  - Label shall include phase identification and circuit number.
- .6.3 All work performed on lead sheathed, medium voltage (1 kV to 35 kV) cables shall be performed only by personnel who have been tested and certified by UTHVS to be qualified. Contractor personnel approved by UTHVS as certified lead-cable splicers shall perform Paper Insulated Lead Covered (PILC) to PILC Splices and shall use UTHVS approved materials utilizing historical lead-wiping methods.
- .6.4 PILC to Polymeric Splices (and PILC to PILC) wye, X and straight shall meet the requirements of ANSI/IEEE 404 (Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2,500 V to 500,000 V, most current version) for 15 kV 133% voltage rating. It must be rated for continuous operation at 105°C, with an emergency overload rating of 130°C. The joint manufacturer shall provide a test report, upon request, demonstrating the joint performance is equivalent to the cables per relevant sections of IEEE-48 (Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV, most current version), IEEE 404 (Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 to 500000 V, most current version), AEIC-1, most current version. The joints shall be subjected to a UTHVS approved voltage withstand test sequence. The splice shall include a solder-less mechanical ground jumper. The splice shall be designed for splicing the types and sizes of power cable used. The splice shall be rated for indoor, outdoor, and immersion in water.
- .6.5 A split-tinned solder connector may be used to join the cables conductors. As an approved alternative to soldering, a 360 degree crimped lug may also be employed. Crimps are to be made by a crimp tool approved by the lug manufacturer following their approved procedures. All crimps shall employ a 360 degree crimp.
- .6.6 UTHVS approved, Raychem factory-manufactured heat shrink splice kits shall be used exclusively.
- .6.7 Kits shall be factory-engineered to contain all necessary materials, except connector, to provide an oil block and oil seal electrical stress control, insulation, shielding and environmental sealing. The kit shall allow for external grounding.
- .6.7.1 Straight splices shall use Raychem Number:
- HVS-1532-LC for 4/0 Cable Poly to Poly
  - HVS-1533-LC for 500 KCMIL Cable Poly to Poly
  - HVS-1582D for 4/0 Cable PILC to Poly
  - HVS-1583D for 500 KCMIL Cable PILC to Poly
  - HVS-1523S for 750 KCMIL Cable Poly to Poly
- .6.7.2 Wye splices shall use Raychem Number:
- HVSY-1522-S for 4/0 Cable Poly to Poly
  - HVSY-1523-S for 500 KCMIL Cable Poly to Poly

- HVSY-1582-D for 4/0 Cable PILC to Poly
  - HVSY-1583-D for 500 KCMIL Cable PILC to Poly
  - HVSY-1523-S for 750 KCMIL Poly to Poly
  - HVSY-1523-MOD for 750-750-4/0 KCM Cable Poly to Poly X splice
- .6.7.3 For 4/0 taps of 500 KCMIL Cable, use 500 KCMIL kit with HVS-shim-3 for 4/0 Cable.
- .6.7.4 In advance of installation with written approval obtained from Utilities UTHVS Management wye, X and straight splices, exclusively for temporary purposes, may be constructed using the following separable cable joints or multi-point junctions:
- 600 Series Deadbreak Separable Cable Joints
  - J Series 15kV EPDM Molded Multi-Point Junctions
- .6.8 Polymeric to Polymeric splices wye, X and straight shall be the same as paragraph .6.7 above except without oil barrier tubing. Joints shall be Raychem HVS-1530-LC series (straight), HVSY-1520S-SC series (wye) with adapters as required for cable type.
- .6.9 Terminations shall meet Class I requirements and be design-proof tested to IEEE Standard 48, most current edition, and be capable of passing a test sequence per IEEE 404, most current edition. Termination kits shall be approved for the type and size of cables used and rated for 15 kV 133%.
- .6.10 Polymeric Terminations shall consist of shrinkable stress control and outer non-tracking silicone rubber insulation tubing with two or greater silicone rubber skirts. In addition, PILC terminations require an oil stop tube. All terminations and splices shall be grounded. Heat-shrinkable tubing shall have high relative permittivity stress relief mastic for insulation shield cutback treatment with a heat-activated sealant for environmental sealing. Termination kits shall be from Raychem Corporation:
- .6.10.1 For 4/0 cables - use type HVT-152-SG for outdoor -unheated areas.
  - .6.10.2 For 500 KCMIL cable - use HVT-153G for indoor or HVT-152-SG for outdoor/unheated areas.
- .6.11 Cold-Shrink splice kits and terminations are prohibited for use on 15 kV and 5 kV class cables.
- .6.12 Potheads may only be used to replace existing potheads in outdoor installations of existing PILC cable.
- .7 PRIMARY VOLTAGE CABLES (5 kV)
- .7.1 5,000-volt service cables shall be UL Listed, 1/c, copper, 115 mil EPR insulated, 15 kV, 133% rated, shielded, MV 105°C cables with low-smoke (260°C spread temperature) zero Halogen. Tape Shield Cables shall have a 5 mil bare copper tape applied helically over the extruded insulation with an average minimum overlap of 25 percent of the tape width. The overall jacket shall be a continuous extruded, 80 mil polyolefin jacket, which meets or exceeds the requirements of ICEA S-93-736, latest edition.

- .7.2 Extension or modification of existing 4,160 volt cables can only be done with prior written approval of UTHVS.
- .7.3 All work performed on 5 kV cable shall be done by qualified individuals subject to the requirements of paragraph .6 above.
  
- .8 Requirements for Application of Fire Tape to Medium Voltage Cables
  - .8.1 Fire tape is applied to an exposed cable for the purpose of protecting that cable from the failure of adjacent cables. For the purposes of this discussion, “exposed cable” refers to cable hung in air or run in ventilated tray. Cable in conduit requires taping only where the cable enters and exits the conduit. Cable vaults and manholes are areas commonly associated with the need to fire tape, however the criteria governing fire taping is broader and may call for taping in other areas of a substation or industrial facility where there are extensive runs of MV cable such as are found in chiller plants and power plants.
  - .8.2 The application of fire tape serves two purposes. It limits the proximal damage caused by a cable failure and reduces the probability that a cable failure will result in the loss of redundant circuits. This is true for instances where there is a little risk of a general area fire caused by a large combustible inventory. Where an area fire is a serious concern, the recommended solution is to re-route critical cables and/or their redundant cables. The application of fire tape to cables in or out of trays offers some protection from an area fire of limited duration and intensity. Where there is little or no risk of an area or tray fire, adding barriers to trays containing redundant cables or placing redundant cables in separate trays is an acceptable alternative design approach.

33 71 73. ELECTRIC UTILITY SERVICES

.1 PRIMARY SERVICE

- .1.1 PRIMARY SERVICE DROPS: Primary service drops and their associated equipment applications are strictly regulated for acceptability of design, impact on power system reliability, safety to University personnel, and human error concern. Other considerations include Codes and Standards compliance, personnel access, switching flexibility, aesthetics and design consistency. A design review and Primary Electrical Service Policy: [https://fod.osu.edu/sites/default/files/primary\\_electrical\\_service.pdf](https://fod.osu.edu/sites/default/files/primary_electrical_service.pdf) is in place to insure that all primary services meet the applicable requirements for design, reliability, maintenance and operation. See Figure 2 for examples of approved configurations for Primary Service Drops are available from UTHVS. UTHVS maintains a listing of approved switch manufacturers, and designs.

Principal responsibility for the design of the low voltage portions of the service rests with Engineer designing pursuant to the requirements of DIV 26 of the BDS and conformant to the requirements of this document. OSU Utilities will inspect all MV circuits and equipment prior to service energization and conduct a low voltage switchgear readiness inspection that covers completeness, housekeeping and safety considerations such as

signage. The formal inspection and determination of readiness for energization of the low voltage portions of the Service rests with the Project and the inspection authority(s) for the building. Utilities inspection of the low voltage portions of the building service does not in any way constitute a formal building inspection as would be routinely conducted by designated State and Local authorities.

- .1.2 PRIMARY SELECT SWITCHES and SERVICE CONNECTIONS: Primary switches and service connections shall be fused load break designs with an interrupt rating greater than the maximum primary feeder fault duty (9600 amps). All new and upgraded Primary Select switches are to be SF<sub>6</sub> (Gas) switches. The use of air break switches is restricted to switch applications such as transfers and equipment disconnection that do not serve a Primary Select function and will not be operated routinely by UTHVS personnel. Primary switches shall employ fully insulated bus. Exposed energized bus terminations and connection points are to be taped or booted. All bus connections are to be bolted or brazed. All internal bus jumpers and connecting cables are to be made with 15 kV cable. Internal jumpers and connections to mating equipment such as primary transformers are to be made with unshielded 15 kV rated cable. All jumpers or connectors routed outside the switch to components remote from the switch cabinets are to be made with 15 kV shielded cable of a construction compliant with the requirements of this Standard. Jumper cables shall be terminated in crimped lugs in conformance with the requirements set forth in this Standard for medium voltage cable termination. Power cables are to be terminated in UTHVS approved solid, long barrel, plated lugs secured with two or more bolts. Crimps are to be made by a crimp tool approved by the lug manufacturer following their approved procedures. All crimps shall be six point or more. A 360 degree crimp is preferred. In instances where the equipment accepting the termination does not support two or more bolts, UTHVS shall be consulted and will determine the acceptability of the single bolt termination. Mechanical type connectors are not generally considered acceptable for power applications.

.2 PRIMARY SELECT SWITCHES - MEDIUM VOLTAGE

- .2.1 A medium voltage service shall consist of a set of primary lightning/surge arrestors (line side of primary select), primary selective switches, fused primary disconnect switches, lightning/surge arrestors (load side of primary disconnect), medium voltage transformer, and low voltage unit substation application section. See Figure 2.
- .2.2 The transformer primary fuses shall be located in an accessible area but shall not be located within the transformer enclosure.
- .2.3 If the anticipated load requires a transformer larger than 1,500 KVA, or if the interruption of building power for maintenance of the low voltage unit substation is unacceptable, then the low voltage unit substation shall be double-ended with the appropriate number of primary selective switches, two separately fused primary disconnect switches, two transformers, and two low voltage sections with a tie breaker provided. On double-ended substations, the main secondary breakers shall be sized per requirements of Division 26.



- .2.4 For critical installations, such as a Hospitals, research laboratories, vivaria, or computer centers, a complete double ended switchgear lineup shall be provided consisting of:
  - .2.4.1 A pair of Primary Select Switches with cross-tie
  - .2.4.2 Two sets of fused primary disconnect switches, two sets of lightning/surge arrestors, two medium voltage transformers, and two low voltage sections with the main breakers and tie breaker
  - .2.4.3 Secondary bus tie and busses shall be sized for the emergency ratings of the transformers.
  - .2.4.4 Secondary Mains and Tie breakers shall be rackable, metal enclosed electrically operated, with provisions for remote operation from a location outside the arc flash area.
  - .2.4.5 Utilities may require specific Medium Voltage switch and cable arrangements for buildings with large distribution load requirements in order the facilitate power distribution system load balancing.
- .2.5 Primary Select Switches shall be rated electrically and mechanically for a minimum of 1,000 load break operations.
- .2.6 The Primary Select switches for the incoming power to each building shall be located outside or in a dedicated switch room directly accessible from the outside at ground level. When located inside a building, the Primary Select switch must be in plain sight from the point of entry to the building or within twenty (20) feet of entering into a building. The room containing the Primary Select switch shall be of a two-hour fire rated construction. The switch must be directly accessible from the outside. Primary cable pull boxes and conduit, ahead of the current limiting fuses shall not be located in or above public occupied areas.
- .2.7 Indoor applications shall be rodent proof and have drip shields to protect exposed High Voltage surfaces; outdoor applications shall be rodent and weatherproof. Switches shall not have floors. Switches shall be constructed to provide safe access to terminals without de-energizing the switch. Switches and bussing shall use porcelain insulators throughout. Switches shall be built on a specially designed pre-cast vaults, raised channel or I-beams, or minimum six (6) inch height concrete slabs above finished grade. The choice of mounting system shall be coordinated with OSU Utilities UTHVS and be approved by UTHVS.
- .2.8 There shall be provisions to protect outdoor mounted switches and associated enclosures from physical damage from Building and Grounds maintenance equipment and private, commercial or delivery vehicles (mowers, tractors, motor vehicles).
- .2.9 Switches shall not be placed in open underground or below grade vaults subject to flooding.
- .2.10 Gas switch handles and elbows shall face the front of the switch enclosure.
- .2.11 In primary select applications, low profile SF<sub>6</sub> switches are to be applied exclusively where electrical cable access permits. Adequate termination space must be provided to accommodate elbow fuses if approved in writing

- by UTHVS (TSG consulting), stress cones and minimum cable bend radius. The termination space provided shall not require bending the cable in the area of the stress cone.
- .2.12 SF<sub>6</sub> switch gear design shall be three-phase, 15 kV, and shall be rated 60 Hz, 600 amps minimum continuous, load break, and pad mount for outdoor at grade type applications. The switch shall be three phase with 3-way, 4-way, 5-way, or 6-way circuit configurations as required and may be provided with a tie switch. Load ways shall be rated at a minimum 600 A; but are generally fitted with 200 AMP deep well load break bushings unless inappropriate for the application. The choice of Primary Select configuration must be coordinated with Utilities UTHVS and be approved by UTHVS as it is first and foremost a part of the Campus Medium Voltage Distribution System.
  - .2.13 The switch shall be equipped with an automatic transfer capability. This includes automatic transfer to an alternate power supply upon loss of voltage on the preferred feeder. The switch shall also be equipped with user friendly, Human-Machine Interface (HMI) that allows personnel to set and adjust parameters for operation, maintenance and configuration. The UTHVS shall be the sole judge as to whether or not this transfer shall be set up as automatic transfer, or shall be set up as manual transfer.
  - .2.14 Switch housings shall be installed to provide sufficient safe access for switching and maintenance personnel.
  - .2.15 Cable connection points to the Primary Select switch shall all be 600-amp dead break bushing for incoming cables and 600-amp apparatus or 200 A deep well load break bushings as required for the switch design. Bushings shall be welded, not gasketed. The switch tank shall be stainless steel with all welded construction. Self-contained switch tripping protection, when required, shall be a three-phase resettable fault interrupter (RFI) field adjustable simulating E fuses. Load ways shall be either RFI or gas switch equipped in accordance with the technical requirements of the installation. An RFI is required when the load way powers a transformer through a fused air break disconnect switch. A gas switch is required when the transformer is supplied through a fuse directly and there is no air break switch installed. Power and sensing for the fault interrupter control shall be supplied by integral current transformers and not require auxiliary power or batteries. Power for the Transfer control is normally supplied from a CPT connected through a fuse to a bus tap in the switch. A dedicated building power fed at 120 VAC may also be provided in place of this feed if the Primary Select Switch is located inside a building and building power source is secure. A battery back-up is required and provided with the switch.
  - .2.16 The minimum Primary connection shall consist of one Primary Selective switch (three way) with two primary feeds off two associated primary pairs. Building specific usage and design considerations shall determine the appropriate number of primary switch ways, and fused sub-switches. Single-phase Primary transformer connections are prohibited. UTHVS shall establish the required Primary Selective switch configuration for each Primary Service based upon a careful evaluation of building service requirements and what is appropriate for the campus power system.

- .2.17 A primary selective switch may be used to provide primary power to as many as four sub-switches or transformers through separate load ways and fuses. The maximum number of transformers that can be powered on a single way is dependent on the acceptability of simultaneous transformer outages for the buildings or services involved. The general practice is to have no more than one building in outage for a single transformer outage.
  - .2.18 Multiple buildings may be fed from one primary select switch equipped with multiple load ways.
  - .2.19 The primary selective switch shall not be used as a junction box or a tie point to provide power to another building when two transformers are not in the same building or room.
  - 2.20 Provide intermediate class, 10 kV, 8.4 kV MCOV (Maximum Continuous line-to-neutral Operating Voltage) polymer enclosed surge arresters on the line side of all primary select switches, and on the load side of all fused primary disconnect switches. Arresters shall be mounted inside of the switchgear compartment with the line side cables they are protecting. Arresters shall be mounted and connected in a manner to be easily disconnected for Hi potting or Hi potential testing of cables.
  - .2.21 When the primary select switch is equipped with electronic fuse emulation, the chosen characteristic must provide coordination with the fused primary disconnect switch fuse.
  - .2.22 Doors to primary select switches shall be key-locked with locks and cylinders complying with the BDS standard of Best Access System key cylinders with removable 7-pin cores. Refer to DIVISION 8 for further details. In addition to the locking provision, a seven flat tamper resistant security bolting shall be provided to reduce the likelihood of unauthorized access to live parts and connections.
- .3 PRIMARY DISCONNECT SWITCHES
- .3.1 Air switch handles, fuses, and elbows (if used) shall face the front of the switch enclosure.
  - .3.2 Primary disconnect air switches shall be a minimum rated 600 amp, 15 kV, stored energy, load break fault interrupting switches. The switches shall be capable of being operated with the operator standing safely away from the front of the switch.
  - .3.3 Primary air break switches shall be Kirk key interlocked. Spare keys shall be provided to UTHVS. Both switches shall be capable of being closed at the same time, paralleled, and provided the spare key is used. Both fuse compartment doors shall be key-interlocked with the switches. The spare key shall permit opening the fuse compartment doors with the switch closed.
  - .3.4 All medium voltage switches shall be top fed with fuses (if used) below the switch. The switchblades shall pivot at the bottom (load side). Provide bussing to the top of the switch, if the switch enclosure is to be bottom feed.
  - .3.5 Doors to fused primary disconnect switches shall be key-locked with locks and cylinders complying with the BDS standard of Best Access System key cylinders with removable 7-pin cores. Refer to DIVISION 8 for further details.

.4 GENERAL

- .4.1 Where applied, fuses shall be E fuses sized to provide thermal short circuit protection to the transformer and effective fault current limiting.
- .4.2 The selected E fuse shall be applied to the Primary of the Transformer based on the size (KVA) of the transformer. The fuse chosen shall accommodate transformer inrush and the ANSI damage curve.

**TABLE # 1 RECOMMENDED FUSE SIZES**

<b>TRANSFORMER RATING KVA@13.2kV</b>	<b>FLA</b>	<b>MINIMUM</b>	<b>133% DRY TYPE DOUBLE-ENDED</b>
112.5	4.9	10E	10E
150	6.6	10E	10E
225	9.8	15E	15E
300	13	15E	20E
500	22	25E	30E
750	33	40E	50E
1000	44	50E	65E
1500	66	80E	100E
2000	88	100E	125E
2500	109	125E	150E
3000	131	150E	200E

- .4.3 All locks shall have manufacturer furnished covers and be provided with two sets of keys. Contractor is to provide all spare keys to UTHVS.
- .4.4 Switch access door handles shall have provisions for padlocks or other locking means acceptable to UTHVS in both the open and closed positions. Front and rear compartment doors shall be hinged and have provisions for padlocks. If a door is required to be opened to operate a switch, the door shall be hinged on the opposite side from the switch handle.
- .4.5 Padlocks for all fused primary disconnect switch handles (open and closed position); doors, and panels shall be supplied by the contractor. At final UTHVS inspection and acceptance, contractor shall supply all locks with a Utility approved core. Keys for these padlocks shall not to be provided to the contractor(s). All padlocks shall be able to accept BEST 7 pin interchangeable cores.
- .4.6 Electric Heaters: All fused primary disconnect air switches located outdoor or located in unheated rooms shall be equipped with electric heaters, the size of the heaters shall be 500 watts/cubicle front and rear. The power supply to the heaters shall be from the secondary side of the transformer or from a reliable, labeled, and supervised building power source.
- .4.7 Tempered viewing windows shall be provided through which it shall be possible to verify that all phases are opened or closed. All air break primary disconnect switches shall have visible contact with a 6" minimum break. Switch contact status for gas switches or vacuum switches shall be derived from positive position sensing of the primary contacts and be visually inspectable with the switch energized.

- .4.8 Insulation: All medium voltage connections, bus bars, and devices in switchgear shall be insulated. Insulated barriers shall not be allowed to come in contact with insulated conductors and shall maintain a 3" clearance. A minimum of 6" clearance shall be observed as minimum required spacing for insulated and uninsulated barriers from uninsulated conductors.
  - .4.9 All primary switches shall be marked on the front by the switch handle with the feeder numbers and phases identified by 1" x 3" engraved, plastic tags screwed to front door or panel near the handle.
  - .4.10 The electrical contractor shall be responsible for ensuring that a level concrete pad is provided. Electrical gear must be installed plumb and level on a concrete pad or mounted on rails embedded in a level concrete pad.
- .5 SWITCHGEAR - LOW VOLTAGE
- 5.1 The trip settings on the Secondary Main shall support proper coordination with the Primary Transformer fuses and any intervening devices. The A/E and Contractor shall provide design and As-Built settings and coordination information prior to Primary Service initial energization. See DIVISION 26, for specific requirements concerning sizing of facility distribution system, arc flash, coordination study, load flow, and short circuit analysis.
  - .5.2 The Secondary Mains and Secondary Bus tie breakers, where they exist, shall be fully rated, metal clad, draw-out circuit breakers. The breakers shall be electrically operated both for close and for trip. A control station shall be provided and mounted external from the switchgear, located outside the arc flash hazard boundary, for remote closing and tripping of the secondary main and secondary bus tie breakers. The maximum operating force required to manually open or close a switch or breaker shall not be greater than 75 pounds force applied to the operating handle.
  - .5.3 Building Emergency generation shall be designed so that no single failure of switching equipment or controls can result in back-feeding the primary transformer and inadvertently energizing the Primary system.
- .6 DISTRIBUTED GENERATION
- .6.1 Generation sources intended to be run in parallel with the OSU MV Distribution System are required to meet the appropriate provisions of the Ohio Revised Code and IEEE standards in addition to the following OSU Electrical Utility requirements for interface of Distributed Generation (DG):
    - .6.1.1 A primary safety consideration of DG systems interconnected to the OSU Electric Utility is that the DG system shall disconnect from a de-energized distribution service irrespective of connected loads or other generators. This is to prevent the back-feeding of the service, which could create a hazardous situation for OSU utility personnel and facility maintenance personnel. A distribution service can be de-energized for several reasons. De-energization can be caused by a substation feeder breaker opening due to fault conditions or the distribution feeder may be de-energized for maintenance or construction reasons.

- .6.1.2 When the interface voltage deviates outside the range of chart below, the DG shall disconnect from the point of electrical interface to the Utility or facility distribution system. This applies to any phase of the three phase system.

Voltage	Maximum Trip Time
$V < 45\%$	10 cycles
$45\% \leq V < 60\%$	60 cycles
$60\% \leq V < 88\%$	120 cycles
$110\% < V < 120\%$	60 cycles
$V \geq 120\%$	10 cycles

- .6.1.3 When the interface frequency exceeds the bounds of 59.5 Hz to 60.5 Hz for longer than 2 seconds, the DG system shall disconnect from the OSU Electric Utility.
  - .6.1.4 Following DG system disconnects as a result of an out of bounds voltage or frequency event, the DG system shall remain disconnected until OSU utility service voltage has recovered to within acceptable voltage and frequency limits for at least 1 minute or until manually reset.
  - .6.1.5 The DG system shall not inject dc into the ac interface under normal or abnormal conditions. An isolation transformer connected between the power conditioning subsystems and the ac interface is one approved method that can be used to satisfy this requirement.
  - .6.1.6 The DG system and interfacing equipment shall be grounded in accord with other appropriate sections of the BDS DIV 33 and or DIV 26.
  - .6.1.7 The DG shall have surge protection in accord with this standard as well as comply with local and national codes.
  - .6.1.8 A lockable, visible, and accessible manual load break disconnect switch shall be provided for control by OSU Utility personnel
- .6.2 Permitting of Distributed Resources
- .6.2.1 Distributed generation sources on Campus for connection to the OSU Campus MV Distribution System either directly or through a building service require a thorough review by OSU Utilities UTHVS at the planning, design and startup phases. OSU Utilities will review the initial application for connection and continue to coordinate with the local utility throughout the planning, design and installation.
  - .6.2.2 Requirements imposed by the University on Distributed Generation go beyond design and initial installation and include routine testing and power quality monitoring. Depending on the type of Distributed Generation involved, there may be other constraints imposed relating to such considerations as time of day switching and loading, circuit loading limits and operational constraints based on Distribution System operating constraints and accommodating

emergency system conditions. Permitting Distributed Generation is not a guarantee of access to the OSU Distribution System. Granting access to the OSU Medium Voltage Distribution System remains at the discretion of OSU Utilities.

**33 72 00.**

**UTILITY SUBSTATIONS**

**33 72 33.**

**SUBSTATION CONTROL HOUSES AND ASSOCIATED FACILITIES**

**.1**

**WIRE AND CABLE**

.1.1 Copper conductors of 98 percent conductivity shall be used unless use is restricted by Government Agencies. Aluminum conductors are prohibited.

.1.2 **COLOR CODING**

Color coding for 480/277V and 208/120V shall be as follows:

Phase	Voltage 480/277	Voltage 208/120
Neutral (Each with identifiable colored stripe)	White or Gray	White
A	Brown	Black
B	Orange	Red
C	Yellow	Blue
Equipment Ground	Green w/Yellow stripe	Green or Bare

**.2**

**LOW VOLTAGE CABLE (600 volt): For Power, Control and Protection**

.2.1 Solid and Stranded Wire: No 12 AWG and smaller may be solid. No 10 and larger shall be stranded.

.2.2 Minimum size for all 125 V DC and 124/240 V AC branch circuits is No 12 AWG.

.2.3 Use of minimum No 14 AWG stranded for AC control wiring and auxiliary system circuits is permitted.

.2.4 Use of No 12 AWG, or greater, for 125 V DC control wiring is required.

.2.5 Use of No 10 AWG for all current transformer circuit wiring is required.

.2.6 Use No 16 AWG TSP or TSQ for instrumentation analog current loop or voltage signal.

.2.7 General Use insulation for 600 volt rated wire and cable shall be NEC, 600 volt class type XHHW2 with SIS allowed for power component internal control wiring. Jacketing shall be Low Smoke Zero Halogen. Nylon conductor jackets and the use of PVC for conductor insulation or jacketing are prohibited for Utility applications. All wiring between equipment, cabinets or control panels for low voltage power equipment power and control circuits shall be in conduit or tray. All control wiring between power components, cabinets and control panels shall be in jacketed color coded cables bearing suitable durable cable identifiers. Cable conductor color coding shall conform to ICEA Method 1 table E2. Panel and component wiring shall have individual wire labels. Wiring shall not be color coded. Acceptable labeling conventions include: destination labeling, unique wire numbering.

.2.8 Power cables are to be terminated in UTHVS approved solid, long barrel, plated lugs. Power cables carrying high current (greater than 50 Amps) shall

have two or more bolts. Crimps are to be made by a crimp tool approved by the lug manufacturer following their approved procedures. All crimps shall be six point or more. A 360 degree crimp is preferred. In instances where the equipment taking the termination does not support two or more bolts, UTHVS shall be consulted and will determine the acceptability of the single bolt termination. Mechanical type connectors are not considered acceptable for power applications.

- .3 INSTRUMENTATION (300 volt class and below)
  - .3.1 Use of minimum No 16 AWG for all analog instrument circuit wiring is required.
  - .3.2 Use of manufacturers approved plenum rated cable for all communications and digitally based signal cables is required within Substation Control Houses, Power Plants, Regional Chilled Water Plants, and Associated Facilities.
  
- .4 GENERAL REQUIREMENTS FOR CONTROL AND INSTRUMENTATION
  - .4.1 AC and DC control circuits shall not be run in the same control cable. Low level (< 50 volts) instrument cables shall not be run in conduit or in tray shared by power or 110 volt AC, 125 volt DC control cables. Note: 120 VAC PLC inputs may be treated as instrument cable for the purposes of determining tray system placement. 120 volt AC and 125 volt DC branch circuits providing control power to equipment and systems shall be run via color coded jacketed cable of approved construction from the point or origin at the source distribution panel to the point of connection at the equipment, control panel, switchgear or enclosure. These cables shall be classified as control cable not power cable. These requirements pertain to all branch circuits providing control power to electrical and I&C equipment with wire sizes AWG 10 or smaller. AWG 8 and larger are exempted from the color coded, jacketed cable requirement.
  - .4.2 All control panel, control cabinet and switchgear wiring No 10 AWG and smaller shall be landed on UTHVS approved terminal blocks. Stranded wire termination shall be with approved ring type solid uninsulated barrel design. No more than two wires shall be terminated on any screw type terminal point. Thread on wire nuts or split bolt connectors are prohibited. In-line control wire splices are not acceptable for new installations. Control cable butt splicing for modifications or upgrades is permitted with prior written approval of UTHVS. Butt splices in control and instrument cable conductors shall be made with the appropriate sized Butt Connectors and insulated with electrical tape or approved heat shrink tubing with appropriate shimming.
  - .4.3 All control components are to be secured firmly to their supporting structures. Self-adhesive fasteners and thermo plastic fasteners are not acceptable.
  - .4.4 All cable and wiring that is field run to control panels or equipment enclosures shall be terminated on UTHVS approved terminal blocks. Landing field wires directly on serviceable components is prohibited. Small local control stations, local starters and local instruments may be excluded from this requirement. Purchased equipment and systems may come supplied with high density terminations. Termination of stranded wire to high density terminal blocks, or



to terminal blocks that employ pressure type terminal clamping, shall be via ferrule. In instances where the use of ferrules is not practical, the wires are to be stripped to allow enough exposed conductor to permit full penetration into the terminal and tinned to form a solid conductor. Terminations made to terminal blocks that employ a pressure type terminal shall have conductor insulation extend up to the block and not show exposed conductor. High density screw or post type terminations, where permitted, shall employ insulated barrel lugs where necessary to maintain adequate electrical clearance between adjacent terminations

- .4.5 All current transformer secondary circuits shall be wired through shorting type terminal blocks.
- .4.6 All control cabinet and enclosure control wiring shall be dressed neatly, bundled and laced. Heavy duty UV resistant tie-wraps are an acceptable method of lacing. In general, Panduit or wire raceways shall not be used to organize wiring. Panduit may be used subject to OSU Utilities UTHVS approval to organize and support control wiring in high density applications. Cable bundles shall be supported at regular intervals. Generally lacing to cabinet mounted tie points is an acceptable approach. Self-adhesive tie-downs are not acceptable.
- .4.7 Every reasonable effort shall be made to separate 480 V equipment and circuits from control wiring. 480 V components and wiring shall be mounted separate from control components and provided separate access. Control components accessed for operations or maintenance shall not share the same enclosure with the power switching components or exposed power wiring without adequate protection from accidental contact by personnel or tools.
- .4.8 In instances where low voltage (125 volts or less) control components and wiring must be housed in a common enclosure with power circuits (208 volts or above), exposed power circuit conductor surfaces shall be provided with a barrier to reduce the likelihood of accidental shock or burn.
- .4.9 The preferred configuration for the separation of power and control is to have the power cabinet separate and to the side of the control cabinet. If this is not possible, the power cabinet and components should be mounted above rather than below the control cabinet or panel. Points of interface between control and power circuits, such as control transformers, shall be located with the power equipment. Secondary (control) fuses shall be located in the control area, not on the control transformer or in the power area.
- .4.10 Adequate consideration shall be given to the operating temperature environment for temperature sensitive components. Electronics shall be mounted below the mid-plane of their housing enclosure. Sources of heat generation such as transformers and power supplies shall be mounted above, not under temperature sensitive equipment and enclosures shall be sized to operate closed without forced ventilation or the need for fans or filters. A maximum of 10°C temperature rise is allowed on enclosures for equipment rated 60°C or less. This shall be verified by heat run test or analysis and the rise shall be measured at the top of the enclosure.

- .4.11 All control cables entering control cabinets and enclosures shall be secured by their jackets to a cabinet or enclosure support to provide a strain relief for the cable wire terminations.
  - .4.12 Control wiring traversing hinges or other forms of flexible constructions shall be high stranded and shall traverse the area of bending normal to the plane of rotation so as to impart a twisting rather than a bending motion to the cable or wire bundle.
- .5 CONDUIT and FITTINGS
- .5.1 Conduits shall be galvanized rigid steel. The use of EMT or aluminum for conduit or fittings is strictly prohibited for power and control circuits within Substation Control Houses, Power Plants, Regional Chilled Water Plants, and Associated Facilities. Fiberglass conduit may be used in tunnels or basements where wet conditions persist, only by written approval from UTHVS (TSG consulting). The fiberglass conduit installation shall be filament wound reinforced epoxy manufactured in accordance with the latest revision of NEMA TC 2002 and UL 1684. The manufacturer selected shall offer a full line of fittings, adaptors and elbows manufactured from the same materials and process as the conduit. Joining shall be by compatible adhesive or in areas where expansion or contraction may be a concern, the use of an EPDM gasket O-ring in a tapered bell to provide a non-adhesive, moisture resistant mechanical joint is acceptable. Acceptable systems are Champion Fiberglass and United Fiberglass. Fiberglass conduit is prohibited for general use or in explosion hazard areas (Class I Div II or more stringent). Where appropriate for the application, the materials used to manufacture conduits, raceways, ducts, boxes, equipment enclosures, and the finished products shall conform to the latest edition of NFPA 130, NPA 502, NFPA 70(NAC) and shall have the capability to withstand high temperatures up to 500°F, low temperatures down to -60°F and have a maximum 2 hour rating of up to 1850°F.
  - .5.2 Conduit carrying power conductors shall be sized for the number and gauge of the wire contained. The minimum conduit size allowed is 1-inch conduit. NEC requirements for conductor count and fill shall be followed, except for control cables, and where specifically waived by UTHVS.
  - .5.3 Pull boxes shall be spaced at appropriate intervals to allow for pulling cable and not exceeding the manufacturer's maximum pulling tension or sidewall pressures.
  - .5.4 Cable minimum bend radius limits shall be observed for all cables during installation and in the final installed condition. "L" boxes shall not be used for shielded power cables, multi-conductor control or instrument cables with more than four conductors of AWG #14 wire or greater.
  - .5.5 Conduits and boxes shall be routed and installed clear of traffic areas, equipment access lay-down or removal areas, mechanical equipment subject to high temperatures or movement or thermal displacement.
  - .5.6 Conduit shall be supported at regular intervals in both the vertical and horizontal directions.
  - .5.7 Multiple circuit power cables shall have all three phases and ground present in each conduit.

- .5.8 All rigid steel conduits shall be provided with grounding bushings.
  - .5.9 Fittings for rigid steel conduit shall be galvanized steel, threaded, 2" diameter and below with insulated throats, 2.5" and above with grounding bushings. Compression fittings are permitted where use of threaded fittings are not practical, based on prior approval by UTHVS. Setscrew type fittings are prohibited.
- .6 TRAY
- .6.1 Tray may be used for power, control or instrument cable in areas known to be free from significant dirt or debris accumulation, physical, and explosion hazards.
  - .6.2 Power tray shall be ventilated, expanded metal or ladder construction. In mildly corrosive or damp environments galvanized steel tray is required or conduit shall be used. Multi-circuit power cables shall have their phase circuits transposed to avoid heating from circulating currents in the tray. Power cables are defined as cables supplying power to motor driven equipment, heaters, transformers etc. or power distribution panels where the loading of the cable may be substantial. Branch circuits serving only control loads with low to negligible circuit loading should be treated as control.
  - .6.3 Control and Instrument tray may be ventilated or enclosed construction, solid metal, expanded metal or ladder construction. In mildly corrosive or damp environments, galvanized steel tray is required or conduit shall be used. The tray shall be closed and covered in areas where excessive dirt accumulation is anticipated.
  - .6.4 Tray shall be grounded. A continuous 4/0 stranded bare copper conductor shall be run the length of the tray clamped or bonded to each tray section and run to building ground directly or to building steel at regular intervals along the tray run, not to exceed 100 lineal feet of tray. This ground cable shall be run external to the tray and not placed in the tray with the electrical cables.
  - .6.5 All trays shall be sized for the intended loading and supported at regular intervals to building structural elements. Supporting tray from equipment, ductwork, pipes or pipe hangers is prohibited.
- .7 DC BATTERY SYSTEM
- .7.1 Battery
    - .7.1.1 A central substation battery system operating isolated from ground at a nominal 125 VDC is provided. The battery must be rated to handle worst-case switchgear and anticipated DC system loads for a minimum of 8 hours from an 80% charge condition. Battery cells shall be connected in series to achieve the desired battery terminal voltage. Battery cells shall be rated for the entire ampere-hour rating of the battery. Paralleling of cell strings is not acceptable.
    - .7.1.2 Batteries shall be located in clean dry and temperature controlled areas. They shall not be located within one foot of uninsulated outside walls to insure uniform cell temperatures are maintained. If batteries are contained in self standing enclosed cabinets this one foot limitation may be reduced to 3". In cases where batteries are

located near insulated walls, batteries and or their cabinets shall be placed so as to insure an air space to allow free movement of room air. Batteries and battery cabinets are not to be mounted on or against exterior walls.

- .7.1.3 Central DC system batteries shall be of the Substation type rechargeable wet cell design. They shall have a 20-year service life or better and be contained in transparent jars deigned to facilitate the inspection of the battery internals. The jar size (number of individual cells contained) shall be limited to what can be managed for replacement by two persons. The entire battery shall be housed in a ventilated, lockable enclosure. The selection of battery technology shall appropriately reflect the service requirements and the ratings and limitations of the powered equipment.

#### .7.2 Battery Charger

- .7.2.1 A dedicated Battery charger is provided that is rated to handle full dead battery charging current simultaneously with normal DC system continuous loads. The battery charger shall be rated to carry the DC system normal continuous load and recharge the battery from a 100% discharged state in a maximum of 16 hours.
- .7.2.2 Battery chargers shall be located in clean dry and temperature controlled areas.
- .7.2.3 The battery charger must be designed to maintain a float voltage on the battery while carrying the DC system load and be rated to support full DC system load currents for a worst case switching scenario.
- .7.2.4 The battery charger must be designed to apply a programmed equalizing charge to the battery manufacturers' requirements.
- .7.2.5 The battery charger shall have an output breaker sized to automatically isolate the charger from the DC system battery for an internal charger fault without loss of DC system load or opening of the battery output breaker/fuse.
- .7.2.6 The battery distribution system shall be designed to facilitate the use of a load bank for periodic battery discharge testing. Such testing shall be conducted without the need to shut down any DC system loads either for connection of the bank or during the test itself. For redundant battery systems, the system shall be designed to accommodate the test battery's load from the redundant battery without the need for DC power interruption, or temporary connections. For single battery systems, the system shall be designed to allow all loads to be powered directly off the battery charge(s) without the need for DC power interruption, or temporary connections prior to or during discharge testing.

#### .7.3 DC System

- .7.3.1 The DC system must be supplied with:
  - Battery voltage and current indication

- Ground detection and alarming
- Off-nominal voltage and alarming
- Charger failure alarming
- Alarming for loss of charger AC power

Note: See Figures 6 and 7 for typical DC metering panel

- .7.3.2 DC system protection shall be provided either by selectively applied Fuses or Circuit breakers. Protection is designed to isolate and eliminate faults. Battery and main distribution circuit fuses and breakers shall be sized to accommodate the short circuit duty of the system. If provided with a main breaker or fuse, the battery powered DC system circuit breaker or fuse shall be rated to ride through all DC system load faults.
- .7.3.3 DC system loads shall be restricted to loads required for the safe and reliable operation of the power system.
- .7.3.4 The normal source of power to DC loads shall be the battery charger. In critical applications the University may require redundant battery chargers aligned in a primary and backup configuration. Switching shall be accomplished with a transfer switch or through the use of output isolation devices in each charger. An acceptable alternative to two (2) permanently installed chargers is a cross-tie to another battery system or a provision to attach a temporary charger.
- .7.3.5 The battery is the principal source of power. The system control, monitoring, provisions for maintenance and protection shall reflect this.
- .7.3.6 DC System loads shall not require a battery tap, but shall be designed to operate at full battery voltage under normal and equalize voltage conditions. The use of low voltage control devices with series resistors is discouraged with the exception of indicating lamps that require series fusing for circuit reliability reasons.
- .7.3.7 Surge or transient suppression schemes that can provide a short circuit path between battery positive and negative or from battery positive and negative to ground shall be fused.
- .7.3.8 All circuit alarming and monitoring devices connected to the DC Battery System shall be protected by breaker or fuse.

.8 Annunciators

- .8.1 Local annunciators and remote annunciators shall be equipped with identical displays. All annunciators and remote annunciators shall be fully supervised, and the annunciator system shall be self-monitoring. The alarm state on the annunciators shall remain locked in until manually reset.
- .8.2 Annunciation shall be provided to support the maintenance and operational needs of the system or equipment being monitored. Individual annunciation points shall be grouped into one of three categories:
  - .8.2.1 Operations (critical) - Operations alarms are alarms requiring prompt remedial corrective action.

- .8.2.2 Maintenance (non-critical) - Maintenance alarms are alarms for conditions that need to be addressed in a planned or routine manner.
  - .8.2.3 Status (informational) - Status alarms are alarms that provide information on the condition or change of state of equipment that might be of interest but of limited immediate concern to operations or maintenance staff.
  - .8.2.4 Operations and maintenance alarms must be communicated to a manned location. Local annunciation shall be provided only in instances where the operators or maintenance personnel can be expected to require this information to be presented locally.
- .8.3 Annunciator power shall be supplied from the plant or substation 125 VDC system. Communications relaying the annunciator activity to a remote manned location shall also be powered from the plant or substation 125 VDC system.
- .9 LIGHTING
- .9.1 The lighting design shall provide for both task and access/egress lighting.
  - .9.2 Task lighting shall be at illumination levels appropriate for reading labels, metering, test instruments, and written instructions.
  - .9.3 Access/Egress lighting levels shall be adequate to insure that personnel gaining access to and traversing high voltage areas or leaving those areas can move safely and efficiently without concern for obstacles, tripping and bumping hazards.

**33 73 00.**

**UTILITY TRANSFORMERS**

.1 GENERAL

- .1.1 Position transformers for proper cooling, service, replacement and expansion room for future capacity addition.
- .1.2 Indoor dry type and liquid type transformers shall be power cast or resibloc-cast Dry Type, or silicon filled. In Dry type designs, both HV and LV windings shall each be separately cast as one rigid tubular coil. Indoor liquid filled transformers are not approved for general use as Primary transformers (see Section .1.4.2).
- .1.3 Outdoor transformers shall be either pad mounted liquid filled or substation liquid filled type.
- .1.4 Liquid filled pad mount and dry type transformers shall have a low loss, amorphous metal core. If other domain refined grain oriented silicon steels are used rather than amorphous metal core to achieve high performance unit then, the Manufacturer(s) must supply to the UTHVS and TSG the Certified Test Reports (CTR) referencing actual data taken from the units ordered for related project and the electrical, thermal and audible noise requirements. Measurements taken must meet the requirements of NIST Standards. Insulating fluid shall be type 2 mineral oil, silicone, FR 3 or an alternative fluid approved for use in the intended application by the University. Liquid-filled

transformers shall be labeled as to the type of dielectric fluid contained in the transformer.

.1.4.1 No-load losses for new primary service transformers shall not exceed the following:

Transformer Size	No-Load Losses
• 300 KVA	532 Watts
• 500 KVA	650 Watts
• 750 KVA	830 Watts
• 1,000 KVA	1,000 Watts
• 1,500 KVA	1,300 Watts
• 2,000 KVA	1,660 Watts
• 2,500 KVA	2,050 Watts
• 3,000 KVA	2,500 Watts
• >3,000 KVA*	

\*Any proposed design for a transformer 3,000 KVA or larger must be submitted by the A/E for prior review and approval by UTHVS and TSG. Submittal must include proposed load-losses, no-load-losses, and auxiliary losses and will be subjected to an economic comparison based on the estimated present worth of the combined losses over the service life of the transformer.

.1.4.2 Note: The requirements of this section apply in whole to all new installations. When the transformer application is for a repair or replacement or an upgrade to an existing building; one or more of the above requirements may be relaxed with the written consent from UTHVS and TSG, through the Project Manager.

.1.5 Primary winding shall be 13.2 kV 3 phase connected Delta. The secondary winding shall be connected grounded Wye. Primary winding shall be equipped with no load tap changing switch with a nominal tap and two 2½% taps above rated voltage, plus two 2½% taps below rated voltage. Special applications may require different secondary connections. Any variance from the specified configuration to meet the service requirements of an application must be reviewed and approved by Technical Service Group (TSG) and UTHVS.

.1.6 The transformer coils shall be wound of electrical grade copper and continuous wound construction; aluminum windings are prohibited.

.1.6.1 Transformers applied in primary service shall be supplied with a minimum 95 kV BIL on the primary and an appropriate BIL on the secondary (10 kV for 480 V dry type, 30 kV liquid filled).

.1.7 Buildings with critical loads such as research or main computer facilities or medical buildings shall have double ended substations with transformers sized to handle 120% of anticipated maximum normal secondary load without fan cooling or 110% of emergency loading with fan cooling whichever requires the larger self-cooled rating.

.1.8 For liquid-filled transformers, provide pressure-vacuum and liquid level gauges. Provide a temperature gauge with max pointer and alarm contacts.

- Provide fan control on all cooling fan assisted transformers. Liquid-filled transformers shall have an over pressure relief with indicator.
- .1.9 Silicone oil transformer shall be equipped with service Viton gaskets.
  - .1.10 The name of original manufacturer of the transformer shall be identified on the transformer nameplate. If the transformer has been supplied through another manufacturer or vendor, the name of that manufacturer or vendor shall also appear on the nameplate.
  - .1.11 Dry type Primary transformers shall have bolted terminations on their high voltage windings. Liquid-filled Primary transformers shall be provided with Dead Front high side terminations with Dead Break elbows and load break arrestors as well as provisions for grounding and parking stands. All Primary transformers with cabled secondaries shall be provided with adequate secondary termination capacity and termination space to accommodate termination of secondary cable equivalent to twice the thermal capacity of the transformer rating.
  - .1.12 All transformer fans are to be fully guarded. Guarding must be effective for personnel protection and for protecting transformer bus and windings from loose blades and blade assemblies.
  - .1.13 The transformer shall be equipped with Intermediate class polymer enclosed surge arresters to protect the primary of the transformer. Porcelain enclosed arrestors are not acceptable. Arresters shall be 10 kV rated, 8.4 kV MCOV (Maximum Continuous line to neutral Operating Voltage). Locate arresters as close to the transformer primary bushing with phase and ground leads as short as practical.
  - .1.14 The fuses in the primary selective switches and the primary disconnect switches shall be "E" fuses sized to supply and isolate their associated transformer. (See Table 1) If more than one transformer is fed from the same primary select switch or primary disconnect switch, then each shall be separately switched and fused.
  - .1.15 Power transformers shall be housed in their own enclosure and not be located within switchgear or switchboards. Transformer enclosures shall not house primary fuses. Enclosures for Dry Type transformers shall have removable panels on all sides as needed to facilitate access to core, coils, bus work and terminations for inspection and maintenance. Liquid-filled transformer termination enclosures shall provide adequate termination room for both primary and secondary terminations, and a reasonable level of physical separation consistent with the voltages involved. Liquid-filled transformers shall not have any fuses or fusible links inside the tank. All fusing shall be external to the transformer tank and enclosure.
  - .1.16 Outdoor, oil filled transformers shall not be located within ten feet of building openings or fire escapes. If directly opposite a window or door, a blast wall shall be erected.
  - .1.17 Work Space about transformers shall have minimum clear working space of five feet (5'0) to permit ready and safe access for preventative maintenance, emergency repair and inspection.
  - .1.18 The transformer load and secondary bus voltage regulation requirements of the design, and practical fault limits of the applied switchgear, shall determine



the Primary Transformer impedance. Low transformer impedance provides good voltage regulation and low flicker but increases the cost of the downstream switchgear and may also interfere with the proper coordination of Primary Transformer fuse and secondary main circuit breaker. It will also increase Arc Flash values and make in-service maintenance more difficult. High impedance can lead to excessive voltage dips on starting large motors and unacceptable levels of flicker in the lighting system. In general, for the size transformers applied as Primary Transformers and the types of loads supplied, the impedance will not need to exceed 7% or be less than 3% on the transformer Base KVA.

- .1.18.1 Acceptable Primary transformer impedances are impedance values that allow for proper coordination between Secondary Main Circuit breaker protection and standard Primary transformer protection without the need to resort to external reactors or current limiting devices, and still provide acceptable voltage regulation for power quality considerations, and acceptable arc flash values. UTHVS reserves the right to deny primary electrical service to any facility that cannot demonstrate proper coordination or fault rating of secondary switchgear. See DIVISION 26 for specific requirements concerning sizing of facility distribution, arc flash, coordination study, load flow, and short circuit analysis.
- .1.18.2 Main and Primary Distribution system Fault, Load Flow, Arc Flash, and Coordination studies are maintained centrally by UTHVS. System fault levels (phase and ground fault currents, X/R ratios and coordination requirements) for I building service connections are available to the A/E for their use in performing facility electrical systems studies, by written request to UTHVS. System fault contribution is established by considering system conditions and possible future system conditions and reconfigurations. On the Columbus campus, the system contribution is 10,000 Amps Three phase, 8500 Amps phase to Ground with an X/R of 30 for both. System Nominal operating voltage is 13.2 kV with a maximum continuous operating voltage of 13.6 kV.
- .1.19 The transformer manufacturer shall provide the ANSI damage curve for the transformer.
- .1.20 Dry type transformers shall be designed for continuous operation at the rated KVA with a nominal 40-year life expectancy and overload capabilities in accordance with the latest ANSI-C57. The temperature rise of these transformers shall be 80°C and the transformer shall be insulated with a UL-recognized 220°C insulation system. Cast or resibloc-cast coil transformers shall employ Nomex 410 (preferred) or Nomex E56 insulation turn to turn with the remainder of the insulation system and encapsulation meeting an overall 185°C insulation class rating.
- .1.21 Liquid-filled transformers shall be designed for continuous operation at the rated KVA with a nominal 40-year life expectancy in accordance to the latest

- ANSI Standards. The temperature rise of these transformers shall be 55°C over a 40°C ambient.
- .1.22 The sound levels of the transformer shall be designed in accordance with ANSI/NEMA recommended levels.
  - .1.23 Transformer enclosures shall match or exceed the NEMA class associated with the location and service chosen for the transformer. The transformer enclosure shall not rely on the addition of external enclosures, hoods or other forms of drip proofing to avoid the risk of spillage or contamination from sources known to be in the area.
  - .1.24 Transformers shall be Factory tested prior to shipment in conformance with the applicable IEEE/ANSI Standards.
  - .1.25 The Primary Transformer enclosure shall not be used as a place to mount metering CT's or a point of connection for cables providing a power to the secondary bus for fire pumps or other loads. Metering CT's and PT's are prohibited from being installed within the primary transformer enclosure. Power taps to serve the Fire Pump are prohibited from being installed within the primary transformer enclosure.
  - .1.26 When hinged-enclosure doors are provided for access to primary transformers, the doors shall be key-locked with locks and cylinders complying with the BDS standard of Best Access System key cylinders with removable 7-pin cores. Refer to DIVISION 8 for further details.

**33 79 00.**

**SITE GROUNDING**

**33 79 19.**

**UTILITIES GROUNDING - ELECTRICAL**

**.1**

**GENERAL**

- .1.1 Station grounding is provided for personnel protection, reduce equipment over-voltage exposure due to lightning, and to control stray voltage caused by static charges and electrical faults. Perimeter grounds are run to reduce the likelihood of personnel experiencing injury from stray contact potential. Equipment case or enclosure grounding serves the same purpose.
- .1.2 The 13.2 kV power system is a multiple grounded design. There are no single phase loads connected phase-to-ground. All major primary power circuits are provided with grounds that run continuously back to the power source. Loads on the system are connected phase to phase. Feeders that traverse the campus to supply building loads are shielded cables with their shields grounded at all splice and termination points.
- .1.3 Grounding of major power components serves the purpose of conducting equipment fault currents safely away with very little increase in local contact potential.

**.2.**

**PRACTICES:**

- .2.1 Design and installation of grounds shall follow IEEE 142 Recommended Practice for Grounding of Industrial and Commercial Power Systems, most current edition.

- .2.2 Submitted designs and Contract Documents shall show ground systems, protective conduit sizes, and relative locations. Specifications and Drawings shall include detailed requirements of the grounding system.
  - .2.3 Grounding systems applied shall at a minimum conform to applicable requirements of the National Electric Safety Code (NESC) for medium voltage installations (13.2 and 5 kV) and the NEC for low voltage installations. Where NEC requirements conflict with this Standard, this Standard shall govern.
  - .2.4 All connections in the primary grounding system shall be clamped, exothermic welded, Cadweld® or equivalent. Individual grounding rods connected to the grounding system shall have a measured ground resistance of ten ohms (10  $\Omega$ ) or less. This measurement may be made by any of the commonly accepted methods for measuring ground rod resistance to earth. Grounding for power equipment power circuit neutral grounding shall be no greater than one tenth ohm (0.1  $\Omega$ ) measured from the neutral bus to the local ground bus or building structural steel. Primary circuit (13.2 kV system) grounding shall conform to the NESC for potential rise during ground fault. Ground resistance shall be no greater than three ohms (3  $\Omega$ ) for cabinet and control circuit grounds. Only copper-to-copper ground connections may be clamped or bolted. With limited exceptions, all other terminations shall be Cadweld®ed.
- .3 SERVICE GROUND
- .3.1 Grounding rods shall be a minimum size of 5/8" x 10' copper clad steel and shall not be placed in back-fill, but driven into undisturbed soil.
  - .3.2 Interconnection of the service ground, system neutral, and equipment ground conductors shall be made within the service equipment.
  - .3.3 All feeder circuit conduits shall include a 4/0 insulated ground conductor. The equipment enclosure (transformer case, etc.) shall not be used as a power grounding path. Two independent paths to a common ground point or ground reference shall ground all high voltage apparatus enclosures.
  - .3.4 Ground conductors shall be 600-volt insulated installed in rigid PVC or rigid galvanized conduit along with the circuit phase conductors. Main and Primary service transformers shall have a bonded secondary neutral that connects to an established ground grid, or grounding system. Cabinet grounds shall be 4/0 solid bare copper and run to an existing grounding system, an adjacent grounded cabinet or, in the absence of an established grounding system, to grounded building steel.
  - .3.5 Except where specifically allowed by UTHVS, all electrical equipment grounding shall be via 4/0 copper conductors. Conductor and insulation when specified shall conform to the following requirements:
    - .3.5.1 4/0 bare solid conductor shall be used in applications where the conductor is placed below grade or in a corrosive environment.
    - .3.5.2 4/0 bare medium stranded (7 strands) may be used in lieu of solid conductor in below grade applications and in mildly corrosive environments, and where conductor flexibility is a consideration.
    - .3.5.3 4/0 bare high stranding (up to 19 strands) is permitted in all above grade applications where exposure to corrosives is not a concern.

- .3.6 All 4/0 bare copper ground cables shall be properly supported:
  - .3.6.1 Solid: supported at 4-foot maximum spacing
  - .3.6.2 Medium stranding: supported at 3-foot maximum spacing
  - .3.6.3 High stranding: supported at 2-foot maximum spacing
  
- .3.7 Ground cables may be required to be insulated based on their use.
  - .3.7.1 Transformer and generator neutrals connected to neutral resistors or reactors to limit ground fault currents must be insulated. Cable insulation shall be line-to-line voltage rated. Ground cables running from the Grounding resistor/reactor and station ground shall be bare 4/0 copper unless specified differently in the design.
  - .3.7.2 Ground cables run in conduit or tray with feeder cables shall be insulated to avoid the possibility of arcing from stray ground currents during a power system ground fault. The insulation system required in this application is 600 volt class.
  
- .4 EQUIPMENT GROUNDING
  - .4.1 All electrical equipment, enclosures and skids are to be provided with safety grounding.
    - .4.1.1 Equipment case grounding shall be via 4/0 bare copper solid conductor. It shall be attached to the grounded equipment via Cadweld® or bolted connection where required to facilitate removal for equipment maintenance. It shall be bonded to an established ground grid, ground system, or grounded building steel.
    - .4.2.2 Each design should have a detailed grounding plan that adequately describes the grounding requirements for the enclosure/skid and also the grounding requirements for major powered electrical components contained therein.
  
  - .4.2 Equipment skids and multiple equipment enclosure line-up shall have two independent 4/0 ground points. For one of these ground points, individual cabinets and small enclosures (e.g. lighting transformers) can utilize the ground carried back to the supply panel with the power cable as long as this conductor carries no load current and is properly identified as a grounding conductor. Multiple groupings of enclosures can have their equipment grounds daisy chained and do not require that both ground paths be direct to building or station ground so long as the maximum ground resistance limitation is observed.
  
  - .4.3 Portions of equipment skid may require separate grounding accommodations where vibration eliminators, non-conductive expansion joints or galvanic protection (isolation points) have been installed. These applications must be referred to the Design authority, UTHVS or the equipment manufacturer to establish the proper grounding design.
  
  - .4.4 Substation buildings and electrical equipment enclosures shall be provided with a continuous ground bus that runs the perimeter of the basement (or lowest) elevation. This ground bus shall be tied to adjacent structures and to the station grounding system at multiple points. As a preferred practice, all

grounds should be run to this bus. An acceptable alternative, equipment and enclosure grounds can be run and bonded to adequately grounded pre-existing equipment skids or building structural steel so long as the maximum ground resistance limitation is observed.

.4.5 Control and Relay panels:

In addition to the required provisions for equipment grounding, control panels shall be provided with an internal ground bus made up of a minimum 2" by ¼" inch copper bar. This bus shall be placed at the bottom or top of the panel front on the interior side and brought to substation ground. Where panels are arranged in multiple panel configurations, the ground bus shall have provisions to connect or jumper between panel sections via a bolted or Cad welded connector. All equipment case grounds, CT grounds, instrument transformer grounds and shielded control and instrument cable grounds shall be brought to this ground bus and connected via ¼" bolted fasteners.

.4.6 Buried control cable and ducts:

Control cables run to locations in the substation below grade in conduit, or where permitted direct buried, shall have all spare conductors grounded at the control panel end of the cable run. In addition a bare copper ground wire shall be placed below the duct bank running the length of the cable run and snaked at roughly 45 degree angle to the control cable. This ground cable shall be attached to substation ground at both ends of the run.

.4.7 Buried Power cable and ducts:

Feeders with each phase contained in a separate conduit in a three phase duct bank array shall be provided with un-insulated ground cables run external to the conduit. The conductors shall be run below the duct bank and bonded to substation ground at both ends of the conduit run. There shall be a minimum of one 4/0 bare copper cable per vertical duct bank column. Three phase arrays with only three ducts arranged in a single vertical column shall be provided with a minimum of two 4/0 bare copper ground cables. Feeders with all three phases and an insulated 4/0 ground cable contained within a conduit require no external ground conductor.

.4.8 Fences (perimeter grounding):

Substation fences shall be provided with continuous buried 4/0 bare copper ground cable run a nominal three to six feet on both sides of the fence and bonded to the fence at fifty foot intervals or less. These cables shall be attached to the substation ground mat at regular intervals. Gates shall be bonded via extra flexible ground leads and the gate opening area shall be ringed with buried 4/0 bare copper ground cables.

.4.9 Yard Operator stations, pads:

Operating positions and step-off pads shall be grounded to the adjacent strictures with 4/0 bare copper cable via two independent paths.

.4.10 Primary Switch Enclosure Grounding:

Primary switches mounted inside buildings or in vaults shall be grounded at two points in conformance with the general requirements for grounding stated in sub-section .2.4 of this section. Enclosures, where provided, are to be grounded to the switch grounding system providing two paths to ground for the enclosure in accordance with Section .4.3. Ground connections to

enclosure are to be bolted onto the inside of the enclosure. The bolting is to facilitate removal of the enclosure for switch maintenance or replacement.

.4.10.1 Primary switches mounted external to buildings on manholes, vaults or housekeeping pads or slabs shall be provided with enclosure touch potential grounding in addition to switch grounding. Grounding rods shall be driven at all four corners of the pad at a distance of 4' 3" from the pad. A single 4/0 bare copper conductor shall be bonded to and run between the four rods at a distance of 3' from the edge of the concrete, forming a loop. Two 4/0 copper conductors shall be bonded to the 4/0 loop at opposite corners and bolted to the switch enclosure. These conductors may be bare copper if run exposed or may be insulated. Ground connections to enclosures are to be bolted onto the inside of the enclosure.

.4.10.2 Primary switches with enclosures mounted external to buildings on pavement or a slab extending three feet or more beyond the extremities of the switch enclosure shall be grounded at two points in conformance with the general requirements for grounding stated in sub-section .2.4 of this section. Enclosures are to be grounded to the switch grounding system providing two paths to ground for the enclosure in accordance with Section .4.3. Ground connections to enclosure are to be bolted onto the inside of the enclosure. The bolting is to facilitate removal of the enclosure for switch maintenance or replacement.

.4.10.3 All remote electrical equipment, portable equipment or temporary service switches and outlets are to be grounded. Power panel branch circuits powering duplex outlets shall not be powered through a GFI or ACFI at the source but, if a GFI outlet is required, have the GFI local to, or integral with, the local service connection or outlet.

33 79 93. SITE LIGHTNING PROTECTION

.1 LIGHTNING PROTECTION

.1.1 Buildings and structures shall have lightning protection. This protection shall be designed to effectively protect not only the building but associated electrical structures and major electrical power equipment including transformers and cables.

.1.2 Protection may be afforded through the selective placement of air terminals on the buildings or structures or by shielding through the use of aerial ground wires placed to afford a 30 degree cone of protection.

.1.3 Protection from lightning induced voltage transients and large changes in local ground potential shall be afforded by properly applied lightning arrestors, spark gaps, and surge suppressors.

.1.4 Design and installation shall follow NFPA 780 Standard for the Installation of Lightning Protection Systems, most current edition.

.1.5 See DIVISION 26 for requirements for building/structure lightning protection.

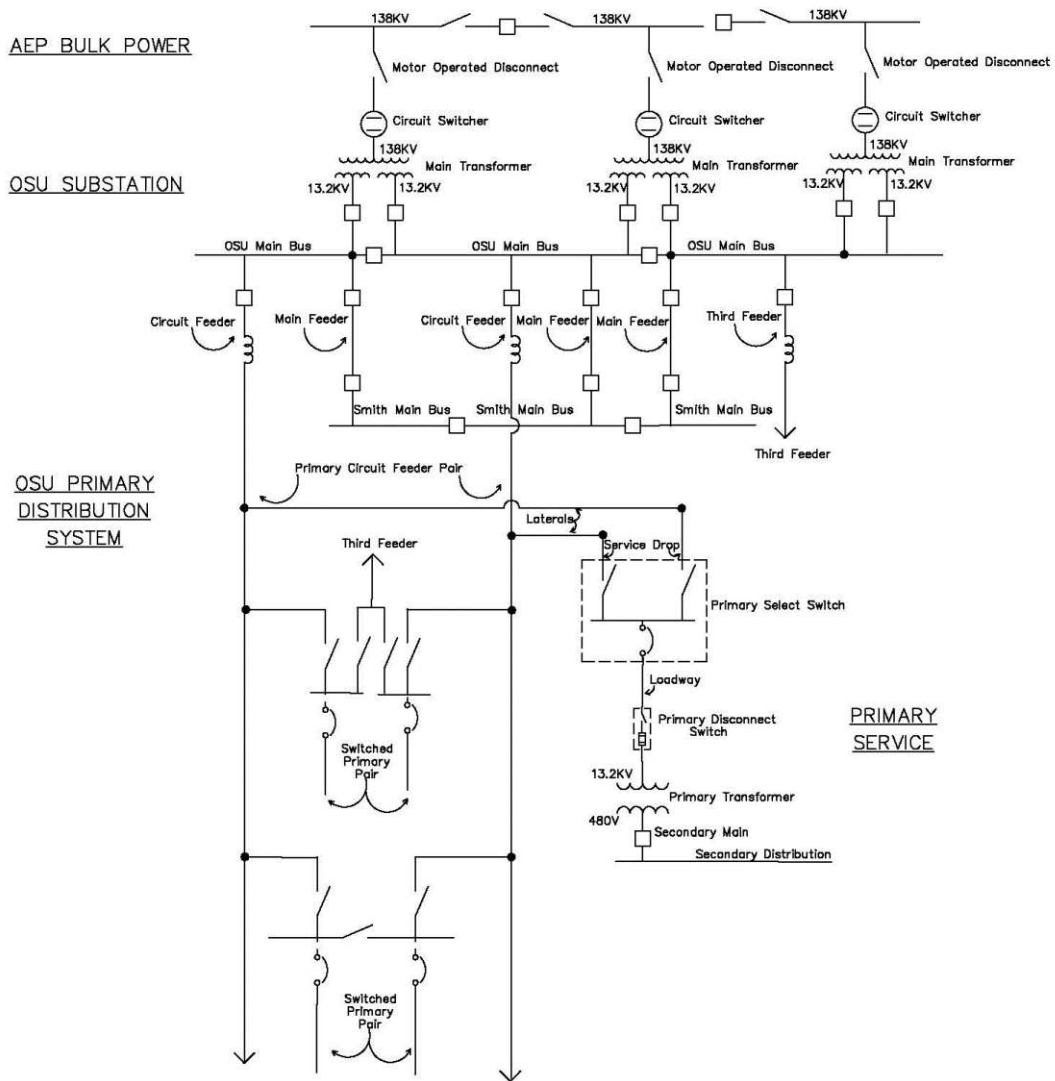


Fig. 1 Electrical One Line

Figure 1

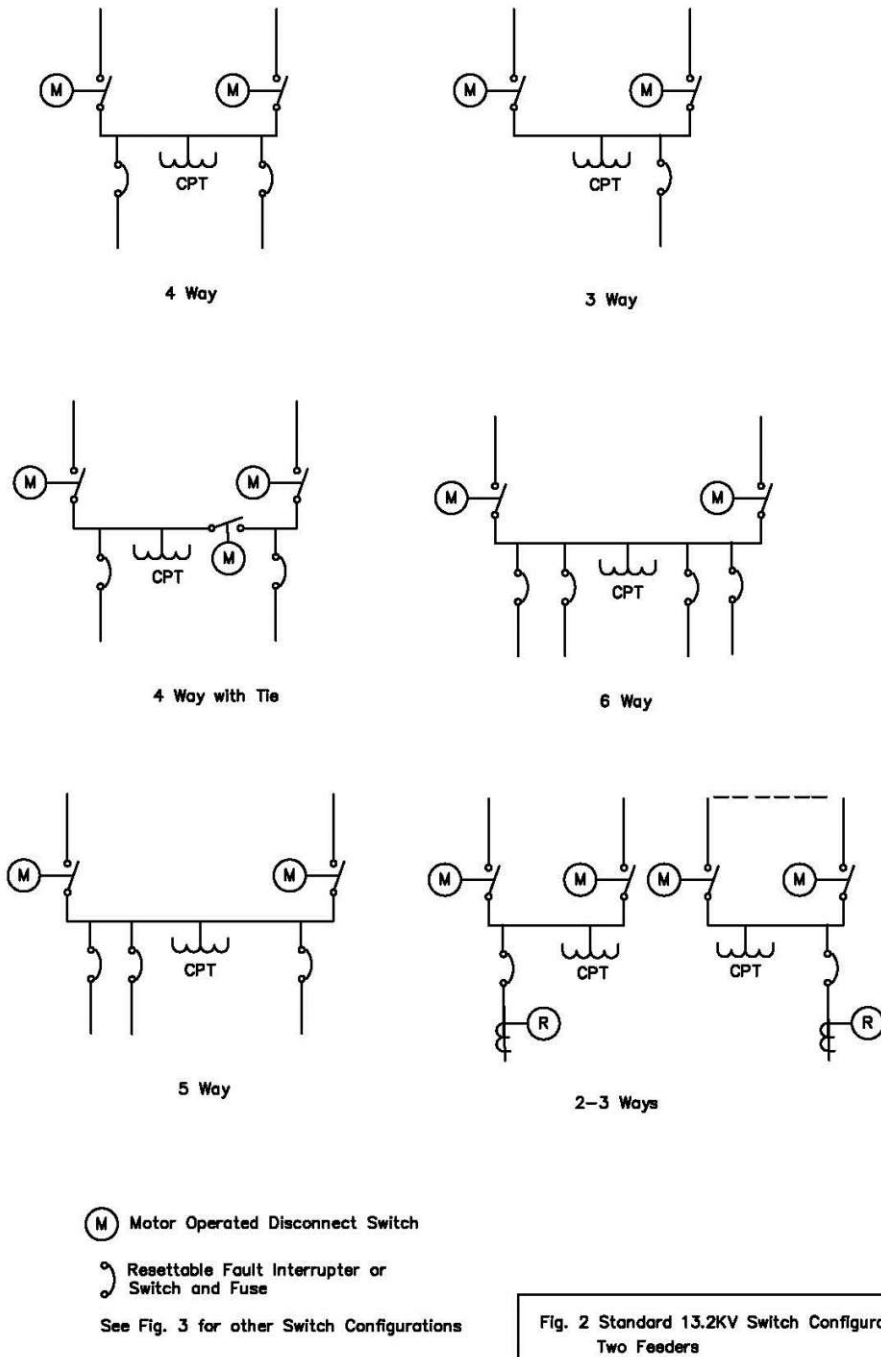
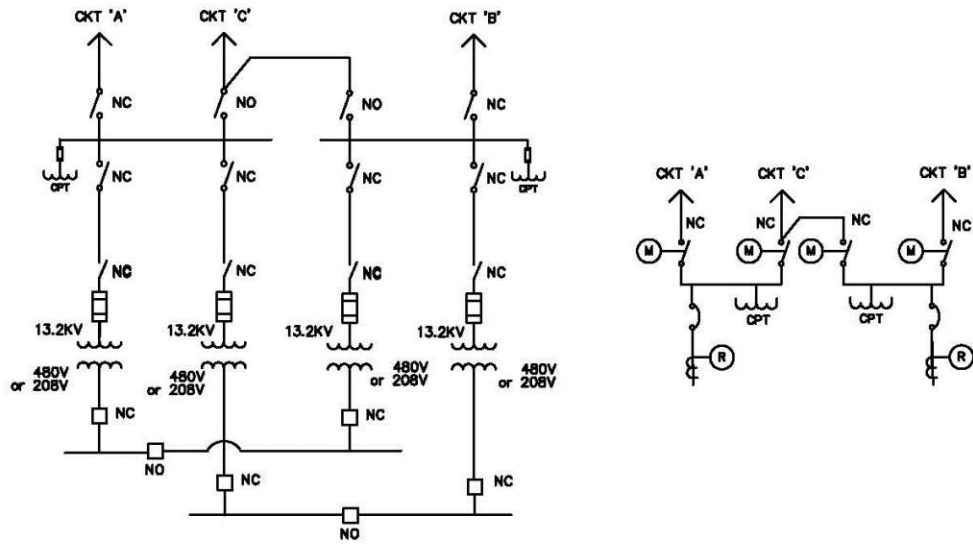


Figure 2





Large Building Complex with Third Feeder

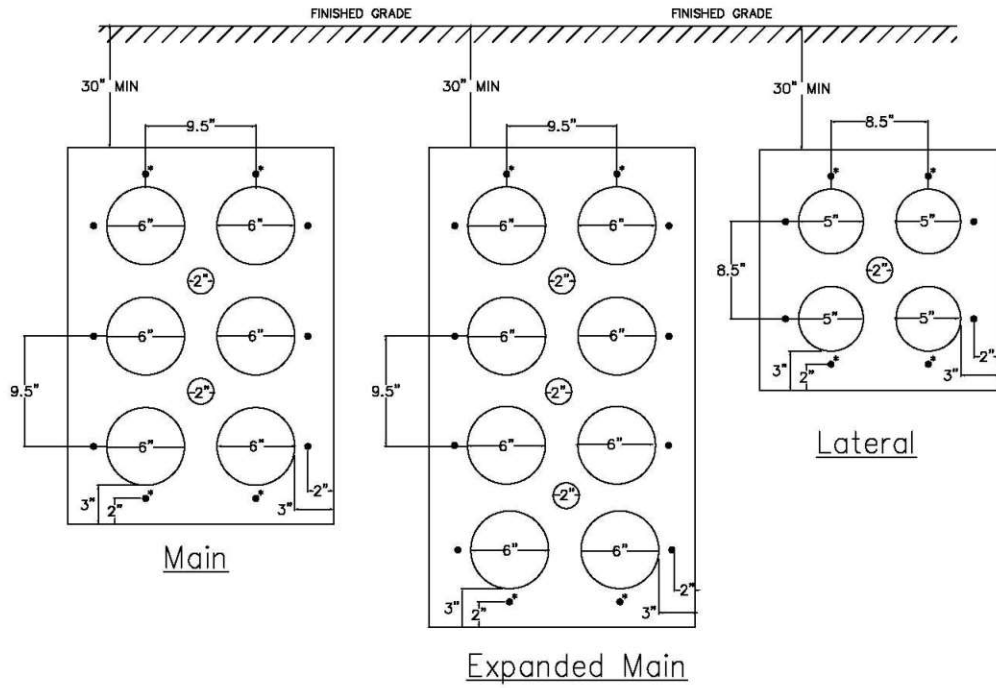
Switched Pair Feeding Branch Circuit

- (M) Motor Operated Disconnect Switch
- (R) Selective Tripping Relay
- ⌋ Circuit Gas Switch or Circuit Interrupter with RFI

See Fig. 2 for other Switch Configurations

Fig 3 Primary Configurations Three Feeders

Figure 3



- SCHEDULE 40 PVC
- #5 REBAR
- \* FOR HEAVY TRAFFIC AREAS AND PARKING LOTS ONLY

Fig 4 Primary Duct Bank Configurations

Figure 4

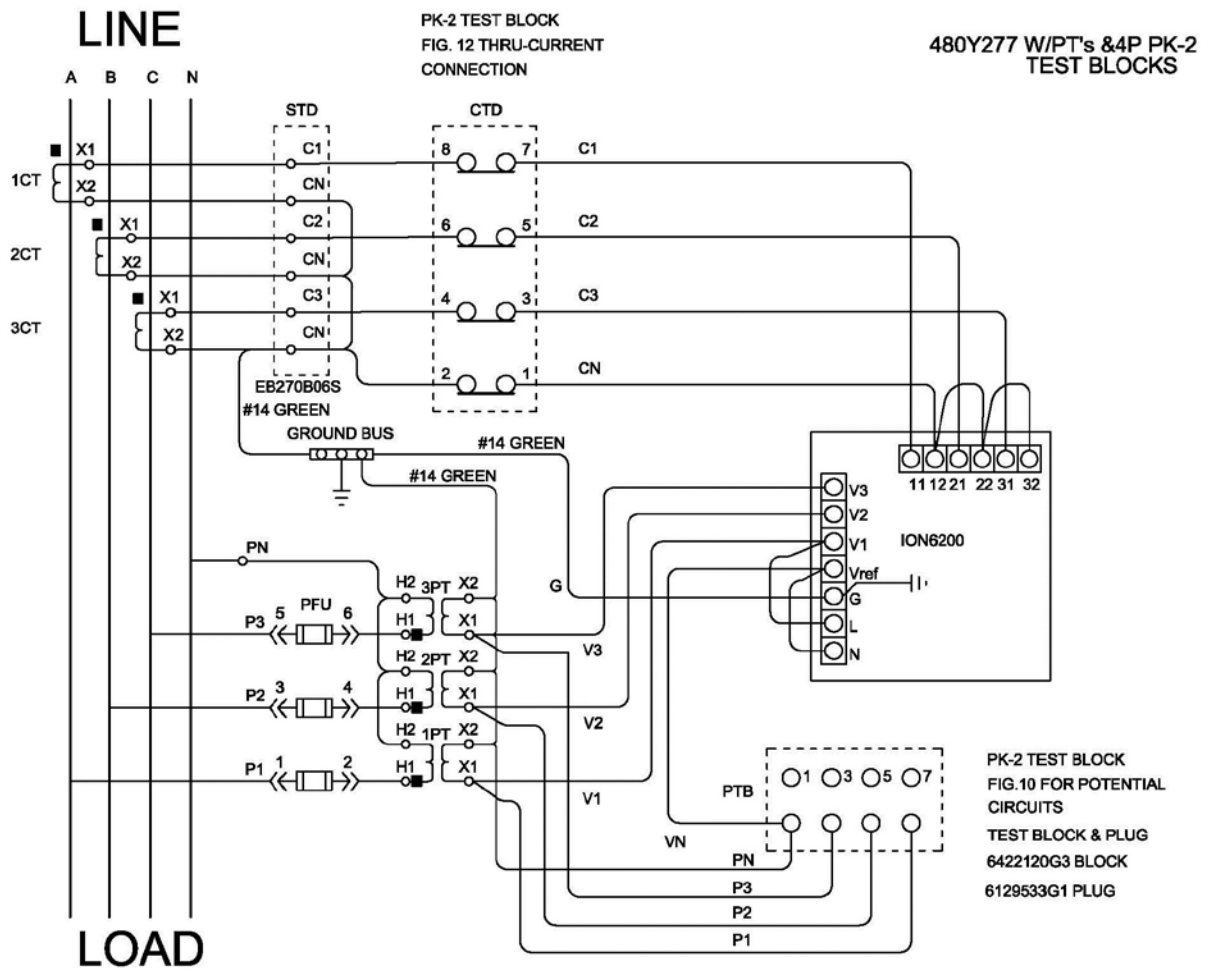
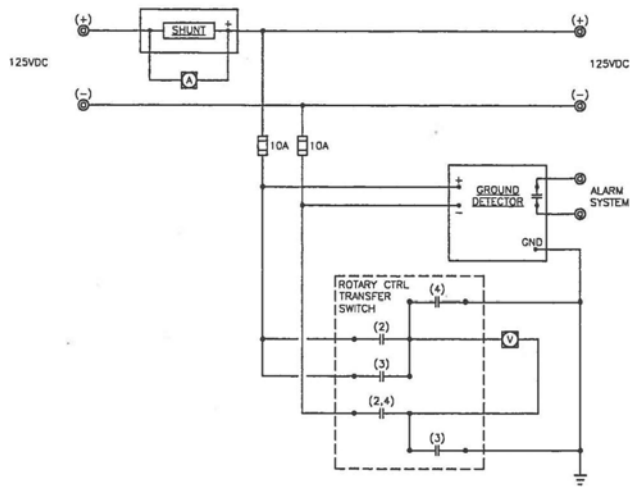


Figure 5



GROUND DETECTOR PANEL PARTS LIST:

- WESCHLER DC VOLTMETER  
STYLE # 691B6712A15  
0-150VDC
- WESCHLER K241 DC AMMETER  
STYLE # 691B671A15  
INPUT RANGE 0-50mV  
INDICATION RANGE 0-50 AMPS DC
- WESCHLER SHUNT  
MODEL # HA-50-50  
50mV DC AMMETER SHUNT
- HOFFMAN ENCLOSURE  
181410CH, 16" X 14"
- HOFFMAN PANEL  
FOR 16" X 14" ENCLOSURE
- BUSSMAN FUSE BLOCK  
BUSSMAN # R600301CR
- BUSSMAN 10AMP FUSES  
BUSSMAN # LPSRK10 SP LPS-RI
- BENDER GROUND FAULT DETECTOR  
BENDER # UC140P
- BENDER MOUNTING PLATE  
SERIES X140
- GE TERMINAL BLOCKS  
GE # EB26D06C
- GE MULTILIN CONTROL TRANSFER SWITCH  
2 STAGE, 4 POSITION  
GE # 165B1BB4385SM2P

GROUND DETECTOR PANEL DETAIL

Figure 6



Figure 7

END OF DIVISION 33 - UTILITIES

## TABLE OF CONTENTS

<b>40 00 00.</b>	<b>PROCESS INTERCONNECTIONS .....</b>	<b>3</b>
<b>40 90 12</b>	<b>METERS AND GAUGES.....</b>	<b>3</b>
<b>40 90 00</b>	<b>INSTRUMENT AND CONTROL FOR PROCESS SYSTEMS .....</b>	<b>7</b>
<b>40 90 02</b>	<b>APPLICABLE INDUSTRY STANDARDS .....</b>	<b>8</b>
<b>40 90 03</b>	<b>CONTROLS PROJECT EXECUTION AND DOCUMENTATION REQUIREMENTS .....</b>	<b>8</b>
<b>40 90 04</b>	<b>PROJECT DELIVERABLES .....</b>	<b>11</b>
<b>40 91 00</b>	<b>PRIMARY PROCESS MEASURING DEVICES.....</b>	<b>12</b>
<b>40 91 13</b>	<b>CHEMICAL PROPERTIES PROCESS MEASUREMENT DEVICES.....</b>	<b>13</b>
<b>40 91 16</b>	<b>ELECTROMAGNETIC PROCESS MEASUREMENT DEVICES .....</b>	<b>13</b>
<b>40 91 19</b>	<b>PHYSICAL PROPERTIES PROCESS MEASUREMENT DEVICES .....</b>	<b>14</b>
<b>40 91 23</b>	<b>FLOW PROCESS MEASUREMENT DEVICES .....</b>	<b>15</b>
<b>40 92 29</b>	<b>CURRENT TO PRESSURE CONVERTORS.....</b>	<b>16</b>
<b>40 92 30</b>	<b>VALVE AND DAMPER POSITIONERS .....</b>	<b>16</b>
<b>40 92 36</b>	<b>LINEAR ACTUATORS .....</b>	<b>16</b>
<b>40 92 43</b>	<b>ROTARY ACTUATORS .....</b>	<b>17</b>
<b>40 92 49</b>	<b>VARIABLE FREQUENCY DRIVES.....</b>	<b>17</b>
<b>40 94 13</b>	<b>DIGITAL PROCESS CONTROLLER COMPUTERS .....</b>	<b>18</b>
<b>40 94 33</b>	<b>HUMAN MACHINE INTERFACES (HMIS).....</b>	<b>19</b>
<b>40 94 43</b>	<b>PROGRAMMABLE LOGIC PROCESS CONTROLLERS .....</b>	<b>20</b>
<b>40 96 41</b>	<b>PROGRAMMABLE LOGIC PROCESS CONTROLLER PROGRAMMING STANDARDS .....</b>	<b>22</b>
<b>40 95 00</b>	<b>PROCESS CONTROL HARDWARE .....</b>	<b>37</b>
<b>40 95 13</b>	<b>PROCESS CONTROL PANELS AND HARDWARE.....</b>	<b>37</b>
<b>40 95 23</b>	<b>PROCESS CONTROL INPUT/OUTPUT MODULES.....</b>	<b>38</b>
<b>40 95 26</b>	<b>PROCESS CONTROL INSTRUMENT AIR PIPING AND DEVICES.....</b>	<b>39</b>

<b>40 95 33</b>	<b>PROCESS CONTROL NETWORKS .....</b>	<b>40</b>
<b>40 95 49</b>	<b>PROCESS CONTROL ROUTERS AND FIREWALLS .....</b>	<b>41</b>
<b>40 95 53</b>	<b>PROCESS CONTROL SWITCHES .....</b>	<b>42</b>
<b>40 95 73</b>	<b>PROCESS CONTROL WIRING .....</b>	<b>43</b>

**40 00 00. PROCESS INTERCONNECTIONS**

**40 90 12 METERS AND GAUGES**

**PART 1 - GENERAL**

**.1 DESCRIPTION OF WORK**

- .1.1 The A/E shall specify that all devices supplied, whether free-standing or provided as part of a packaged equipment unit, shall satisfy the requirements of this Section.
- .1.2 This Section provides the specification for thermometers, thermometer wells, pressure gauges, flow meters, and other related accessories.

**.2 SUBMITTALS**

- .2.1 Shop Drawings and Product Data, A/E shall specify that the Contractor submit the following:

- .2.1.1 Thermometers and Thermometer Wells

- .2.1.1.1 Provide manufacturer's catalog cut sheets for each type of thermometer with range, accuracy, materials, and accessories marked clearly.

- .2.1.2 Pressure Gauges

- .2.1.2.1 Provide manufacturer's catalog cut sheets for each type of pressure gauge with range, accuracy, materials, and accessories marked clearly.

- .2.1.3 Flow Meters: Provide manufacturer's catalog data sheets with range, accuracy, turndown, rating, materials, end connections, dimensions, and accessories marked clearly. Indicate required upstream and downstream pipe diameters of straight pipe to maintain meter accuracy. For pressure and/or temperature measuring devices for compensation, provide data on those devices.

- .2.2 Operation and Maintenance Manuals: The A/E shall specify that the Contractor submit the following:

- .2.2.1 Thermometers

- .3.2.1.1 General maintenance data

- .2.2.2 Pressure Gauges

- .3.2.2.1 General maintenance data

- .2.2.3 Flow Meters

**.3 DELIVERY, STORAGE, AND HANDLING**

- .3.1 Store thermometer, pressure gauges, and flow meters in a dry location, away from the weather, dust, and debris.
- .3.2 Retain shipping flange protective covers and protective coatings during storage.
- .3.3 Inspect items immediately upon arrival and report any irregularities or damage immediately to the manufacturer/supplier and Engineer.

**.4 QUALITY ASSURANCE**

- .4.1 Comply with applicable portions of American Society of Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of gauges and meters.
- .4.2 Conform to ASME B31.1 for all installations.
- .4.3 Certification: Provide thermometers, gauges, and meters whose accuracies are certified by the manufacturer for the specified operating conditions.
- .4.4 Single-source Responsibility: Specify that the Contractor shall obtain each category of thermometers, pressure gauges, and flow meters, from one source and by a single manufacturer.

.5 IDENTIFICATION

- .5.1 Provide an aluminum valve identification tag for each thermometer, and pressure gauge. The tag shall list the area number, device type, and device number, i.e. "PG-8501".

PART 2 - PRODUCTS

.1 THERMOMETER - BIMETAL DIAL

- .1.1 Case and Ring: Type 300 Series stainless steel. Case hermetically sealed. Dial size shall be 3-inch diameter.
- .1.2 Window: Shatterproof glass.
- .1.3 Accuracy: 1% of full scale. An external adjustable screw shall be provided for calibration.
- .1.4 Adjustable Joint: Finish to match case, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, with locking device.
- .1.5 Element: Bi-metallic.
- .1.6 Stem: Type 300 Series stainless steel, 1/4-inch diameter, of length to suit installation and thermowell length, with consideration given to extension for insulation.
- .1.7 Scale: White coated aluminum with permanently marked black etchings.
- .1.8 Range: Units shall appear in Fahrenheit only.

.2 THERMOMETER WELLS

- .2.1 Construction: Type 304 stainless steel with pressure and temperature rating of 2000 psi at 800°F. All thermowells shall be socket weld connection to service pipe.
- .2.2 Stem Length: For piping applications, shall be 1/3 to 1/2 of internal pipe diameter. For combustion air and flue gases, shall be 18 inches long.
- .2.3 Extension for Insulated Piping ("T" Length): Provide extended thermowells so that the bottom of the thermometer extends 2 inches minimum beyond the insulation.
- .2.4 Threaded Cap Nut: With chain permanently fastened to well and cap.

.3 PRESSURE AND DIFFERENTIAL PRESSURE GAUGES

- .3.1 Type: Type 316 stainless steel, 316L stainless steel Bourbon-tube pressure gauge, with bottom stem-mounted connection.
- .3.2 Case: Polypropylene case, turret style, direct mounting style.
- .3.3 Liquid Fill: Silicone liquid filled cases for all liquid applications.



- .3.4 Connector: 316SS with 1/4 inch male NPT.
  - .3.5 Scale: White coated aluminum with permanently marked black etchings.
  - .3.6 Range: Units shall appear in PSIG only, or PSID for differential pressure gauges.
  - .3.7 Accuracy: Per ASME B40.100, accuracy Grade 2A.
  - .3.8 Acceptable Manufacturers: All gauge pressure gauges (not differential pressure) shall be Ashcroft Duragauge Type 1279 with XLL option (Plus! Performance) which minimizes vibration and pulsation issues. Differential pressure gauges shall be Ashcroft Type 1128 with 0 at the 12 o'clock position, accuracy Grade 1A.
- .4 PRESSURE GAUGE ACCESSORIES
- .4.1 Isolation Valves: For all pressure gauges, provide 1/2-inch NPS shutoff valves as designed and specified for the specific piping system. Valves shall be located a minimum of 2 inches outside of insulation.
  - .4.2 Snubber: Not required due to "XLL option" for Ashcroft gauge specified.
  - .4.3 Syphon: On water systems operating above 120°F and for all steam systems, specify fabricated coil syphon or "pig tail" constructed as specified for the specific piping.
- .5 ORIFICE PLATE FLOW METERS
- .5.1 Type and Construction: Square edge type made of 1/8-inch thick Type 316 stainless steel with a minimum 15/32-inch roughness finish and with flatness within 0.010 inches per inch of dam height. Concentric bore tolerance shall comply with ASME Fluid Meters Committee Report and the calculation shall be based on the "L.K. Spinks" calculation method. Upstream tab of plate shall be stamped with plate data.
  - .5.2 Accessories: Specify carbon steel condensate pots for steam service. Specify multi-variable transmitter, including temperature element.
  - .5.3 Accuracy: The A/E shall specify that the orifice plate flow meter shall have an accuracy of  $\pm 1\%$  for a turndown of eight-to-one for the maximum flow listed.
- .6 FLOW NOZZLES
- .6.1 Type and Construction: Long radius flow nozzle manufactured per ASME MFC-3M with  $\pm 2.0\%$  uncertainty of discharge coefficient. Nozzle shall be a fitting that shall be installed between flanges. Nozzle shall be Type 316 stainless steel. Upstream tab of nozzle shall be stamped with design data.
  - .6.2 Accuracy: The flow nozzle shall have an accuracy of  $\pm 1\%$  for a turndown of eight-to-one for the maximum flow listed.
  - .6.3 Acceptable Products: Specify flow nozzle flow meter by the following manufacturer in accordance with this specification:
    - .6.3.1 Rosemount (Daniel)
    - .6.3.2 Yokogawa
  - .6.4 Accessories: Specify flow transmitter. Provide carbon steel condensate pots for steam service.
- .7 VORTEX FLOW METERS

- .7.1 Acceptable products: Specify vortex meters by the following manufacturer in accordance with this specification:
  - .7.1.1 Johnson Yokogawa
  - .7.1.2 Rosemount
- .7.2 General: Specify vortex-style flow meter with electronics for the specific conditions of each meter. The meter shall have no moving parts. Isolation valve feature shall not be provided.
- .7.3 Materials: Body shall be Type 304 SS with ASTM A105 ANSI Class 300 carbon steel flanges. Shedder bar shall be stainless steel. Sensor gasket shall be designed and rated for specified steam services conditions.
- .7.4 Performance:
  - .7.4.1 Accuracy for Feedwater Service: Shall be  $\pm 1\%$  of reading for flow rates with Reynolds Number of 20,000 or greater, and  $\pm 2\%$  of reading for flow rates with Reynolds Number of 5,000 to 20,000. Accuracy shall be corrected for the actual installed upstream and downstream disturbances.
  - .7.4.2 Repeatability:  $\pm 0.2\%$  of reading
  - .7.4.3 Response Time: 0.25 seconds
  - .7.4.4 Pressure and Temperature Compensation: Not required.
  - .7.4.5 Permanent Pressure Loss: Shall be no more than 1.5 PSIG at specified maximum flow for feedwater service.
- .7.5 Electronics:
  - .7.5.1 Output signal shall be 4 to 20 mA.
  - .7.5.2 Meter shall be configurable and diagnostics shall be performed through the DCS over the 4 to 20 mA signal through a digital signal via the Hart protocol. Meter shall be "Smart."
  - .7.5.3 The flow calculation electronics shall incorporate Spectral Signal Processing Technology, Adaptive Filtering, or DSP Converter (depending on manufacturer) which filters signal noise, hydraulic noise, and pipe vibration.
  - .7.5.4 Local Display: Required.
  - .7.5.5 Remote Electronics Housing: Provide where specified with individual meter specifications. Provide a minimum of 30 feet of wiring.
  - .7.5.6 Electronics Housing: Low copper aluminum alloy with epoxy powder-coated finish. Buna-N O-rings or other acceptable material shall be NEMA Type 4X.
  - .7.5.7 Housing Temperature Rating: Ensure that electronics will not be affected by process temperature, especially for steam service meters. Provide remote electronics housing if necessary to satisfy this requirement regardless if remote electronics are specified for meter.
  - .7.5.8 Calibration: Calibrate electronics in factory. Provide factory calibration certificate for each meter.

### PART 3 - EXECUTION

- .1 THERMOMETER INSTALLATION
    - .1.1 Specify that Contractor shall install thermometers in a vertical, upright position and tilted to be easily read by an operator standing on the floor.
    - .1.2 Specify that Contractor shall install where indicated in the Contract Documents.
    - .1.3 Thermometer Wells: Install in pipe coupling or tee as required. Install in vertical upright position. Fill well with oil or graphite and secure cap.
    - .1.4 Verify that thermowell depth is proper for pipe size.
  
  - .2 PRESSURE GAUGE INSTALLATION
    - .2.1 Specify that Contractor shall install pressure gauges in pipe coupling or tee as required. Provide shutoff valve, snubber, and/or syphon as specified. Locate pressure gauge in most readable position.
    - .2.2 Specify that Contractor shall install where indicated in the Contract Documents.
  
  - .3 ADJUSTING AND CLEANING
    - .3.1 Calibration Statement: Calibrate meters and gauges according to manufacturer's written instructions, after installation. Contractor shall provide a written and signed statement indicating that all meters and gauges have been calibrated in accordance with the manufacturer's instructions. Calibration devices shall be NIST traceable. Provide documentation of NIST traceable with calibration documentation.
    - .3.2 Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.
    - .3.3 Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touchup paint.
  
  - .4 METER INSTALLATION
    - .4.1 Specify that the Contractor shall provide all process connections in piping systems to accommodate meter and gauge installation. Process connection type shall be selected by the Contractor to match the actual meter and gauge provided.
    - .4.2 Locate meters away from upstream and downstream disturbances per manufacturer's requirements.
  
  - .5 MAINTENANCE MANUALS
    - .5.1 In maintenance manuals for meters and gauges, include calibration requirements.
- 40 90 00 INSTRUMENT AND CONTROL FOR PROCESS SYSTEMS
- PART 1 - OVERVIEW
- .1 This section is applicable to the following process systems on The Ohio State University main campus operated and maintained by Utilities:
    - .1.1 Power Plant Boilers and auxiliaries
    - .1.2 Power Plant Chillers and auxiliaries
    - .1.3 Water treatment systems and auxiliaries
    - .1.4 Remote chilled water plants
    - .1.5 Standby generation facilities

40 90 02 APPLICABLE INDUSTRY STANDARDS

- ISA SP5-Documentation of Measurement and Controls Systems
- ISA S20-Instrument Specification Forms
- ISA SP12- Electrical Equipment for Hazardous Locations
- ISA SP18- Instrument Signals and Alarms
- ISA SP77- Fossil Power Plant Standards
- ISA SP84- Programmable Electronics Systems for Safety Applications
- ISA SP95- Controls Integration
- ISA SP99- Control System Security
- NIST Standard 800-82 Industrial Control System Security
- IEC 61131
- National Electrical Manufacturers' Association (NEMA)
- NFPA 85
- ANSI

- .1 Code Conflicts: Code and/or standard conflicts shall be brought to the attention of the University and shall be resolved by the University. In the event of differences between codes and standards, the most stringent code or standard shall apply. Whenever reference is made to a specific code or standard, it shall be understood that the latest edition of such reference, as of the date of the proposal, shall govern.

40 90 03 CONTROLS PROJECT EXECUTION AND DOCUMENTATION REQUIREMENTS

- .1 Process Flow Diagram (PFD): A simple process flow diagram shall be generated by the project's A/E or their designated controls integrator. The drawing will contain only general details of the process. Once approved by the University, this drawing will be used to generate the Heat and Material Balance drawing.
- .2 Heat and Material Balance Drawing (HMB): The HMB will be similar to the PFD but contain more in depth design detail for the system. Calculated items such as heat loads, flow rates, dwell times, throughput, and energy expenditures shall be shown on the document.
- .3 Process and Instrumentation Diagrams (P&ID's): The P&IDs shall be a graphical depiction of all instruments, process equipment, and major piping. P&ID's shall follow the ISA S5 standard. Instrument symbols and identifications shall follow ISA-5.1. Graphic symbols on the P&ID that will be for Operator Interface computer display shall follow ISA-5.3.
- .4 Detailed Cost Estimate and Project Schedule: The detailed cost estimate shall be completed in MS Excel spreadsheet format. The project schedule shall be submitted in MS Project format.
- .5 Drawing List: A Master MS Excel Spreadsheet shall be provided for all drawings used in the project. The spreadsheet shall minimally include the following items: Document Index Number, Associated documents, Document Type, Description, Date Created, OSU Drawing Naming Convention (Reference OSU's Electronic File Drawing and Specification Naming Requirements document located under the Utilities tab at the following web link: <https://fod.osu.edu/resources>), and Comments. The Document Type field shall contain the following choices: Block Diagram, Cable Schedule, Graphics, Installation

- Detail, Instrumentation Data Sheet, Interconnection Drawing, Loop Drawing, Panel Layout, Plan Drawing, Power Plan, SAMA drawing, Termination Drawing, and Wiring Diagram.
- .6 Control System Interconnection drawing: This drawing shall show the interconnection between the new system and the plant Distributed Control System.
  - .7 Master Instruments and I/O List Spreadsheet: This spreadsheet will be created early in the project process. All instruments for the project shall be recorded in this spreadsheet by tag name. Items such as description, location, span information, Vendor, Vendor Part#, Physical location, DCS graphics page(s) and I/O termination point shall be included. This spreadsheet will be used for the Commissioning Plan for the system.
  - .8 Instrument Specifications: Instrument specification sheets shall follow the ISA S20 standard.
  - .9 Site Plan and Conduit Routing Drawings: The site plan shall show the location of all new major equipment and control cabinets. A conduit routing plan shall be provided. The conduit routing drawing(s) shall be interference checked. Any interference needing to be relocated shall be noted on the drawing(s) and costs associate with relocating/demolishing interferences shall be included in the project budget.
  - .10 Termination Drawings
    - .10.1 Termination drawings will show wiring details at the module level at the controller. Terminal numbers, power source with fuse number, shield terminations, channel number, and polarity will be shown for each analog module. Wire colors will be shown near the termination. Wiring from the terminals will be shown to the field device. Field device will consist of the Tag Number, Description, and associated Loop Sheet number.
    - .10.2 Digital I/O modules will show power source with fuse number, common, terminal numbers. Field devices will be identified by Tag Number, Description, and Loop Sheet number.
    - .10.3 All types of I/O modules will be fused per manufacturer’s recommendations.
  - .11 Instrument Termination Diagrams and Loop Sheets
    - .11.1 Loop sheets will show both the I/O module and instrument wiring terminations. The I/O module termination will be identified by the Controller Number, Rack Number, Slot Number, and Channel number. The I/O module termination will reference polarity, wire colors, and terminal numbers. Each I/O module termination will also reference the module drawing that it is derived from.
    - .11.2 The instrument wiring terminations will show terminal numbers, polarity, wire colors, and wire label. Each instrument will be identified by its Tag Number, Description, Location, Manufacturer, Model Number, and range.
  - .12 Panel Arrangement Drawings: Panel arrangement drawing will include a general power arrangement drawing and a detailed drawing showing all internal items in the panel. Power arrangement drawings will show the main power feeds and sources (24 VDC and 110 VAC) for each device. A separate Cable Schedule drawing will be provided for each panel.  
The detailed arrangement drawing shall show the full layout to scale in the panel of all devices, terminal blocks, power supplies, mounting hardware, etc. If space allows, a

- spreadsheet with a complete bill of material for the panel will be shown. Otherwise the Bill of Materials will need to be shown on a separate drawing. BOM shall include: Quantity, Manufacturer, Manufacturer's Part Number, and Description.
- .13 Installation Detail Drawings: A typical installation detail drawing for each type of instrument will be provided. Locations for each instrument shall be field checked for potential interferences. The A/E shall specify that all transmitters be installed no more than 5' off the floor or platform and shall be accessible for routine maintenance without a safety harness. The A/E shall specify that all transmitter manifolds and tubing be constructed of stainless steel appropriate for the process. Differential transmitters measuring steam flow shall have condensate pots installed on each tap of the flow device. The pots shall be installed level with each other. Tubing shall be installed so there are no air pockets. The horizontal legs of the stainless steel tubing shall fall a minimum of 1" per foot towards the transmitter. The A/E shall provide details on the drawings for differential transmitter and condensate pot installation. The A/E shall specify that all pneumatic positioners shall be installed with 5 micron oil/air filters and an isolation ball valve. Tubing to positioners and solenoid operated valves will be of hard copper or stainless steel, all which shall be sourced from the plant control air system. If there is no control air available, an automated control air dryer shall be provided as source air for the system.
- .14 Bill of Materials: A complete bill of materials (BOM) for each project shall be provided. BOM will include: Quantity, Manufacturer, Part Number, Description, and distributor.
- .15 Integrated Design Check: Prior to the A/E submitting a Construction Drawing set to the University for review, the A/E shall perform an integrated design check. The design check will verify the interfacing of controls with the current mechanical and electrical drawings and equipment specifications provided by other disciplines. P & ID drawings and the instrument and drawing databases will be finalized after this check.
- .16 Commissioning Plan: Specify a full commissioning plan for the controls system and associated devices. Plan shall include a detailed checklist to commission each controls item installed by the project. Each item shall be specified to be commissioned by factory trained personnel. Each device shall be field verified from the device, to the controller, then to the graphic control screen(s) for the operator. The A/E's control integrator shall be a full time participant in the commissioning of the controls system and lead commissioning in concert with the commissioning agent during instrument and controls startup and commissioning.
- .17 Field Calibration Records: The A/E shall specify that all transmitters, pressure switches, and positioners shall be field calibrated by technicians trained in field calibrations. Each calibration shall be documented on a calibration sheet. Calibration sheets shall have as a minimum: Tag Name, Description, Location, Process variable, Range, Calibrator type and model with last date of certified calibration, and calibration data showing As-Found and As-Left checks. Calibration checks shall be 0-25-50-75-100 percent of range recorded on the calibration sheet. Calibrator shall have a NIST traceable calibration certificate no more than 6 months old.
- .18 Redlines: Changes to engineering design documents during construction shall be captured and maintained by the contractor. While construction is occurring, a fully

maintained set of redline drawings shall be retained at the construction site, accessible by University personnel.

The design engineer will capture all redline changes and incorporate OSU Utilities Drawing Numbering system on the OSU drawing title block at the end of the project and update the drawings “As-Built”. The design engineer shall do a detailed field review of the installation and wiring to insure it matches the “As-Built” drawings.

- .19 Issue for Record Documentation: The following items are required to be submitted to the University in the Close Out documentation of a controls project within 3 months of receiving contractor redlines:
  - .19.1 As-Built drawings on a CD in AutoCAD format and 1-11 X 17 printed set
  - .19.2 O&M Manuals for all installed devices
  - .19.3 Configuration and calibrations sheets for all devices
  - .19.4 Final controller/Operator Interface programming on a CD
  - .19.5 Bill of Materials
  - .19.6 Instrument and drawing database on CD
  - .19.7 Operating and Maintenance procedures
  - .19.8 Licensed software copy included with each instrument that requires special (Vendor) programming software
  - .19.9 Commissioning report
  - .19.10 Final PLC and HMI programs

40 90 04 PROJECT DELIVERABLES

- .1 Schematic Design phase submittals shall contain the following items from the A/E:
  - .1.1 Process flow diagram(s)
  - .1.2 Heat and Material Balance Drawing(s) if required
  - .1.3 Preliminary Process and Instrumentation Diagrams (P&IDs)
  - .1.4 Preliminary Cost Estimate and Schedule
  - .1.5 Preliminary Drawing List
  - .1.6 Preliminary Control System Interconnection Diagram
- .2 Design Development Submittals shall contain the following items from the A/E:
  - .2.1 Final Process and Instrumentation Diagrams (P&IDs)
  - .2.2 Updated Cost Estimate and Schedule
  - .2.3 Updated Drawing List
  - .2.4 Final Control System Interconnection Diagram
  - .2.5 Preliminary Instrumentation Database
  - .2.6 Preliminary Instrument Specification Sheets
  - .2.7 Preliminary Site Plant and Conduit Routing Drawing(s)
  - .2.8 Preliminary Termination Drawings
  - .2.9 Preliminary Loop Sheets
  - .2.10 Preliminary Panel Arrangement Drawings
  - .2.11 Preliminary Installation Detail Drawings
  - .2.12 Preliminary Bill of Materials
  - .2.13 Preliminary Operator Interface mock up
  - .2.14 Preliminary Bid Documents
  - .2.15 Preliminary Commissioning Plan

- .2.16 Preliminary Controller Programming
- .3 Construction Document Submittals shall contain the following items from the A/E:
  - .3.1 Final Cost Estimate and Schedule
  - .3.2 Final for Construction Drawing List
  - .3.3 Final for Construction Instrumentation Database
  - .3.4 Final Site Plant and Conduit Routing Drawing(s)
  - .3.5 Final Termination Drawings
  - .3.6 Final Loop Sheets
  - .3.7 Final Panel Arrangement Drawings
  - .3.8 Final Installation Detail Drawings
  - .3.9 Final Bill of Materials
  - .3.10 Final Operator Interface
  - .3.11 Final Bid Documents
  - .3.12 Final Commissioning Plan
  - .3.13 Controller Programming
  - .3.14 HMI Graphics (both local and DCS graphics)
  - .3.15 Alarm list
- 40 91 00 PRIMARY PROCESS MEASURING DEVICES
  - .1 General Requirements
    - .1.1 Specified and designed instrumentation shall be industrial grade for harsh plant environments that may include heat, cold, dust, water, and vibration. Instrumentation designed to be installed at the floor or basement level shall be rated for temperatures 0 to 140°F. Instrumentation designed to be mounted in high heat area, such as the upper levels of McCracken Power Plant, shall be rated to 180°F. Instrumentation for outdoor installations shall be rated for -20 to 140°F. All instrumentation shall specified to be NEMA Type 3R enclosure or better.
    - .1.2 All electronic analog instrumentation shall be Smart HART (Highway Addressable Remote Transducer) protocol. Specify that Vendors shall provide the latest Device Type Manager (DTM) files with their submittals. Configuration, at minimum, shall be accomplished by using a Fisher 475 HART communicator and the Endress & Hauser Fieldcare system. All transmitters will have the instrument tag in HART configuration of the transmitter. Any instrument requiring special programming software shall have a licensed software copy included with the instrument and specified as part of the project to be turned over to the University.
    - .1.3 Specify that all transmitters shall have a Stainless Steel tag with the manufacturer, model #, tag #, and serial number of the device. Any transmitter connecting to a controller or PLC shall be 2 wire, loop powered, 4-20 ma signal. Transmitters that require external power will be required to use loop power for the 4-20 ma signal. Specify tag numbers shall match the instrumentation tag numbers used on the contract drawing P&IDs.
    - .1.4 Specify that all transmitters shall be mounted between 4 and 5.5 feet from the floor or operating platform. Transmitters shall be mounted so that the LCD reading is visible for operational use and the tubing and wiring is accessible for maintenance.



- .1.5 Specify that all transmitters shall be factory calibrated and have a NIST traceable factory calibration certificate.
- .1.6 Flow meters of any type shall be sized for the piping that it is installed. Piping shall not be reduced/increased in size for the flow meter installation. All flow meters shall be installed per the manufacturers' recommendation for straight pipe diameters upstream and downstream of the flow meter. If the upstream/downstream straight pipe diameters cannot be accomplished, and another type of flow meter cannot be installed in the position, then the mechanical engineer shall redesign the piping system to accommodate the flow meter.

40 91 13 CHEMICAL PROPERTIES PROCESS MEASUREMENT DEVICES

.1 pH/ORP Meter/Transmitter

- .1.1 pH meters shall have a measuring range of 0-14, with a .01 pH resolution, and repeatability of  $\pm 0.01$  pH. This will be across a temperature range of 0 to 80°C. pH meters shall have built-in temperature compensation.
- .1.2 ORP meters shall have a measuring range of -2000 to 2000 mV, with a 1 mV resolution, and repeatability of  $\pm 5$  mV.
- .1.3 Transmitters for the pH/ORP meters shall be capable of both 2 point automatic calibration and manual calibrations.
- .1.4 Approved Vendors: Specify Rosemount and Yokogawa.

40 91 16 ELECTROMAGNETIC PROCESS MEASUREMENT DEVICES

.1 Capacitance Process Level Measurement Devices

- .1.1 The 2-WIRE Capacitance type continuous level transmitter shall produce an output of 4-20 mA, and HART protocol that is proportional to level (PVI). It shall be capable of making the measurement independent of changes in material density and not be affected by the presence of material clinging to the sensing element. The measurement shall be free from the effects of changes in temperature, density or acoustic noise in the vapor space above the level. Calibration shall be accomplished from a HART Communication PC software with a modem connected anywhere in the 2-wire loop. Calibration may be entered in user's choice of engineering units and by entering any two level points not necessarily zero and full. There shall be no easily accessible controls that unauthorized persons could tamper with. The output shall be certified compatible with the HART Protocol specification Revision 5 or later.
- .1.2 The level measuring system shall be intrinsically safe and suitable for installation in Division 1 hazardous areas when supplied from an approved power supply. The electronic unit shall be mounted in an explosion-proof enclosure and be capable of being either located integrally with the sensor or remotely from the sensor up to 150 feet away.
- .1.3 The electronic unit shall be capable of operating in harsh environments with temperature ranges from -40°F to 185°F (-40°C to 85°C) and be protected from corrosion with a NEMA 4X rated housing. The internal circuit boards shall be protected by a conformal (tropicalized) coating.

- .1.4 The electronic unit shall be a single device capable of use over a wide range of level applications by having a capacitance tuning range of 1 to 40,000 pF. The electronic unit shall have provision for field changeable fail-safe (mode), damping, and field changeable phasing in the event the measurement requires such changes to optimize the level reading. The reading shall be free from effects of Radio Frequency Interference (RFI) when plant radios (walkie-talkies) are in the vicinity of the level transmitter. Further, the measurement shall be free from harmful effects of static electricity on the sensing element with discharges up to 10 Amperes being tolerated without damage.
  - .1.5 Approved Vendor: Specify Drexel-Brooks.
  - .2 Conductivity Process Measurement Devices
    - .2.1 Conductivity measurement devices shall consist of a remote mounted probe and a 4-20 ma transmitter with HART protocol. Transmitter shall be loop powered. A local LCD display of the conductivity measurement shall be provided at the transmitter. The remote probe shall be made of materials to withstand the process temperature and pressure. The remote probe shall have a 3/4" seal tight connection at the head to allow the sensing cable to be protected by seal tight and/or conduit. All measurements shall be in micro Siemens. The probe cell constant shall be chosen to insure the normal measured variable is between 30 and 60% of the device full range.
    - .2.2 Approved Vendors: Specify ABB, Rosemount, and Yokogawa.
  - .3 Magnetic Flow Meters
    - .3.1 Magnetic flow meters shall be installed in horizontal runs of piping and may only be used in processes where the meter tube is fully wetted at all times. Meter materials of construction shall be suitable for use in the intended process. Meters that are 4 to 5.5 feet from the floor or platform may have a permanently mounted transmitter on the unit with a local display. Meters that are not at floor/platform level shall have remote transmitters with display mounted to the nearest wall or panel. Transmitters shall be capable of indicating and measuring reverse flow and be able to show reverse flow in the PLC using only the 4-20 ma signal. Meters requiring external (non-loop) power shall use 120 VAC. The meter shall be able to be a source or sink for the 4-20 ma signal, selectable via an internal dip switch.
    - .3.2 Approved Magnetic Flow Meter Vendors: Specify Emerson (Rosemount), ABB, and Yamatake.
- 40 91 19 PHYSICAL PROPERTIES PROCESS MEASUREMENT DEVICES
- .1 Gauge Pressure Transmitters
    - .1.1 Gauge pressure transmitters will be supplied with internal LCD screens to display the Process variable. A stainless steel ball valve will be supplied upstream of the transmitter to isolate it from the process for maintenance purposes. Tubing between the process and the pressure transmitter shall be stainless steel.
    - .1.2 Approved Vendors: Specify Honeywell, Emerson (Rosemount), Siemens, Yokogawa, and ABB.

- .2 Differential Pressure Transmitters
  - .2.1 Differential pressure (DP) transmitters for steam flow or drum level on boilers shall be installed so that the process fluid in the impulse lines is cooled to ambient conditions. For steam measurement or drum level, condensing pots shall be installed near the root process valves. Where 2 condensing pots are required for one transmitter, the pots shall be installed level with each other. Any horizontal SS tubing runs used shall fall towards the transmitter 1" per foot of horizontal run. All differential pressure transmitters will be supplied with a SS 3-valve manifold that is appropriate for the process pressure and temperature.
  - .2.2 Any range < 30" WC shall have a draft range transmitter installed. Transmitters advertising large turndowns such as 400:1 shall not be used in draft range applications.
  
- .3 Temperature Transmitters and sensors
  - .3.1 Temperature transmitters shall be able to use 2-, 3-, or 4-wire RTD's. Thermocouples may not be used for any applications. All RTD's will be 3-wire, wire wound, and spring loaded with a thermowell that extends at least 35% into the process line. Thermowell construction shall be designed per ASME PTC 19.3 and per manufacturer's recommendations for maximum fluid velocity.
  - .3.2 RTD extension cable shall be shielded #18 AWG, 300 volt, solid conductors in twisted pair triads with PVC insulation, polyester wrapping, and extruded PVC jacket, color coded per ISA standards.
  - .3.3 All temperature transmitters shall have local LCD indication of the temperature process variable.
  - .3.4 Approved Transmitter Vendors: Foxboro, Honeywell, Emerson (Rosemount), ABB, and Yokogawa.
  - .3.5 Approved RTD Vendor: Specify Burns Engineering.
  
- .4 Warranties/Spare Parts
  - .4.1 All transmitters and sensors shall be specified to come with a 5-year manufacturer's warranty from date of commissioning. Specifications shall state that the Contractor shall provide one spare of each transmitter type and sensor. The A/E shall be responsible for tracking these items and verifying that the University has received the specified 5-year warranty and spare devices.

40 91 23 FLOW PROCESS MEASUREMENT DEVICES

- .1 Vortex shedding flow meters
  - .1.1 Vortex flow meters may only be used to measure liquid flow. Meters that are 4 to 5.5 feet from the floor or platform may have a permanently mounted transmitter with local display on the unit. Meters that are not at floor level shall have remote transmitters mounted to the nearest wall or panel.
  - .1.2 Approved Vortex shedding flow meters Vendors: Specify Rosemount and Yokogawa.
  
- .2 Differential Pressure Flow Meters (Orifice plate, V-cone, flow nozzle, pitot tube)

- .2.1 Differential pressure flow meters may be used to measure steam, air, oil, and natural gas flows. Steam, gas, and air flows shall be compensated for temperature and pressure conditions by utilizing a Multivariable Transmitter (MVT). If specialized software and computer cables are required to program the MVT, they shall be provided by the project installing the MVT. In cases where compensation is not possible via an MVT, an external flow computer shall be used to compensate for the temperature and pressure conditions and convert the mass flow into a 4-20 mA signal.
- .2.2 Approved Multivariable Transmitter Vendors: Emerson (Rosemount).
- .3 Coriolis flow meters
  - .3.1 Coriolis flow meters shall be used to measure fuel oil flow to boilers. Meters shall be ANSI flanged. Meter accuracy will be at  $\pm 0.2\%$  of actual reading or better for liquid flows. If the meter is connected to a PLC, meter power will be sourced from the PLC cabinet. Meter shall have a local display for flow rates. Meter shall be provided with a NIST traceable calibration certificate for fuel oil.
- .4 Warranties/Spare Parts
  - .4.1 All transmitters and sensors shall be specified to come with a 5-year manufacturer's warranty from date of commissioning. Specifications shall state that the Contractor shall provide one spare of each transmitter type and sensor. The A/E shall be responsible for tracking these items and verifying that the University has received the specified 5-year warranty and spare devices.
- 40 92 29 CURRENT TO PRESSURE CONVERTORS  
Current to Pressure converters, also known as I/P devices are not allowed for use. See 40 92 30 for positioner specifications.
- 40 92 30 VALVE AND DAMPER POSITIONERS
  - .1 All valve and damper air actuators shall utilize SMART/HART Positioners with 4-20 mA feedback. Positioners will have a local display for position percentage and programming purposes. Positioners will be equipped with a 3-port manifold with pressure gauges, all field airlines into the manifold will be stainless steel tubing conforming to ASTM A 269, Grade TP 316. Positioner shall be able to operate actuators with air pressures between 60 and 100 PSIG. A filter/regulator will be installed on the air supply to the positioner. Filter shall provide  $\leq 5$  microns filtration for control air. In the event the positioner cannot be installed 4.0 to 5.5 feet from an operating platform or floor level, a remote positioner will be installed between 4.0 and 5.5 feet from the operating level.
  - .2 Warranty: All positioners shall be provided with a 5-year manufacturer's warranty from date of commissioning. The A/E shall be responsible for tracking these items and verifying that the University has received the specified 5-year warranty.
  - .3 Approved Positioner Vendors: Specify Siemens PS2 and Fisher-Rosemount DVC 6000 series.
- 40 92 36 LINEAR ACTUATORS

- .1 Linear pneumatic valve actuators shall be sized to fully hold the valve against the maximum process differential pressure and spring rate with air to the actuator. If not explicitly stated maximum process differential pressure is to be determined at an upstream pressure 10 percent above maximum inlet pressure and the downstream pressure at atmospheric. Actuators shall be directly mounted to the valve body.
- .2 Single acting (spring return) actuators shall be designed to fail in a safe position on loss of control signal or air pressure. Double-acting actuators shall be designed and specified to fail in last position on loss of control signal or air pressure. On/Off actuators shall be designed and specified with a speed limiting control. Construction shall be rugged type designed for industrial applications, with low sensitivity to vibration and shock.

40 92 43 ROTARY ACTUATORS

- .1 Pneumatic rotary actuators will be designed for 150% of torque requirements at 80 PSI instrument air pressure. Actuators shall be sized to fully hold the valve against the maximum process differential pressure and spring rate with air to the actuator. If not explicitly stated maximum process differential pressure is to be determined at an upstream pressure 10 percent above maximum inlet pressure and the downstream pressure at atmospheric. Actuators will be directly mounted to the valve body.
- .2 Single acting (spring return) actuators shall be designed and specified to fail in a safe position on loss control signal or air pressure. Double acting actuators shall be designed and specified to fail in last position on loss of control signal or air pressure. On/Off actuators shall be designed and specified with a speed limiting control and position switches with a visible indicator that is visible from the operating floor. Construction shall be rugged type designed for industrial applications, with low sensitivity to vibration and shock.
- .3 Rotary actuators shall have a declutchable handwheel to operate the valve should the actuator or positioner fail.
- .4 Electric modulating rotary actuators shall only be used when pneumatic actuators are not practical, for example, valves located outdoors. Electric actuators shall be specified to have the following features:
  - .4.1 4-20 ma control and feedback
  - .4.2 Operable between -40°F to 185°F
  - .4.3 120 VAC drive power
  - .4.4 Configurable action on loss of input signal
  - .4.5 0.1% repeatability of span
  - .4.6 HART communications
  - .4.7 Automatic zero and span calibration
  - .4.8 Low current draw, continuous duty motor that will not coast, overshoot, or overheat under continuous modulation
  - .4.9 Stall protection
  - .4.10 Declutchable handwheel
  - .4.11 Approved Vendor: Specify Beck.

40 92 49 VARIABLE FREQUENCY DRIVES

- .1 Variable Frequency Drives (VFD) controlled by a PLC shall be fully integrated into the PLC utilizing a redundant ControlNet connection. Drives that have integrated bypass starters

shall be started via a digital 120VAC output from the PLC. When in VFD mode, automatic speed control will be via the Controlnet connection to the PLC. The following drive data will be communicated back to the PLC via Controlnet for HMI display and historical use in the controls system:

- .1.1 Speed feedback in RPM
  - .1.2 VFD Hertz
  - .1.3 VFD heat sink temperature
  - .1.4 VFD alarm/fault codes
  - .1.5 VFD status
- .2 Warranty: Variable frequency drives shall have a 2-year manufacturer's warranty from date of commissioning. The A/E shall be responsible for tracking these items and verifying that the University has received the specified 2-year warranty.
- .3 Approved Model: Specify Rockwell Powerflex 750 series.
- .4 VFD's mounted inside enclosures shall have an adjustable din rail mountable industrial thermostat to cycle the cooling fans on only when needed per manufacturer specs.

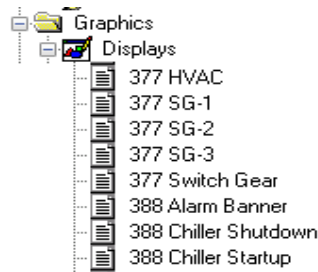
#### 40 94 13 DIGITAL PROCESS CONTROLLER COMPUTERS

- .1 Server Class Process Control Computers: Server grade computers should only be provided if vendor software is not able to be virtualized with VMware. Non-VMware servers shall be from Dell and have the following configuration minimums:
- .1.1 16 GB of memory
  - .1.2 Dual 2.5 GHz quad core processors or greater
  - .1.3 1 TB of Hard disk space utilizing a hardware RAID 5 configuration
  - .1.4 Dual power supplies
  - .1.5 Dual Ethernet connections
  - .1.6 Ethernet Based IDRAC connection
  - .1.7 Rack mounted 2u chassis
  - .1.8 Windows 2012 R2 Operating system
  - .1.9 Microsoft SQL Server 2012 or the software vendor's recommended Microsoft SQL server. (SQL Server Express, Lite, or Embedded is forbidden.)
  - .1.10 5-year, next business day warranty. Warranty shall be transferred to The Ohio State University-Utilities Division.
- .2 Workstation Process Control Computers: Operator workstation computer for process monitoring and control shall have the following minimal configuration:
- .2.1 8 GB of memory
  - .2.2 Dual 500 GB hard drives in a RAID 0 configuration
  - .2.3 2.5 Ghz quad core processor or better
  - .2.4 Redundant Ethernet cards
  - .2.5 Quad monitor video card that meets software vendors specifications
  - .2.6 Provide Windows 7 or 10-64 bit Operating system depending on software vendor's specifications.
  - .2.7 5-year, next business day warranty. Warranty shall be transferred to The Ohio State University-Utilities Division.

40 94 33 HUMAN MACHINE INTERFACES (HMIS)

.1 FactoryTalk View SE HMI

- .1.1 FactoryTalk View SE will be used for Control Room HMI's. The primary use of the HMI is control and monitoring of plant systems. The servers for the FTSE HMI will be redundant and fail over automatically on loss of communications with the Primary server. Servers will be virtualized utilizing VMware vSphere ESXI 5.5 or greater. Project A/E's will be required to estimate the number of added screens needed and insure each project provides licensing for the screens.
- .1.2 P&ID graphics shall be provided that will closely follow the ISA S5 standard. Detailed graphics screens for subsystems shall be provided as required for operator control. Graphic backgrounds will be gray unless otherwise requested. Objects that change state will follow the following color scheme:
  - 1.2.1 Gray- Offline and available to start
  - 1.2.2 Yellow-Offline in Maintenance Mode or unavailable
  - 1.2.3 Blue-Selected to start
  - 1.2.4 Flashing Green-Starting
  - 1.2.5 Green-Running
  - 1.2.6 Red-Faulted
- .1.3 Each graphics screen shall have a row of pushbuttons across the bottom to aid the operator in navigating the system. The following pushbuttons will be required:
  - 1.3.1 Alarm-Opens Current Alarm Screen
  - 1.3.2 Main-Opens screen of pushbuttons with all graphics shortcuts for system
  - 1.3.3 Trend-Opens screen of Trend pushbuttons
  - 1.3.4 Back-Goes back one screen
  - 1.3.5 Equipment Overview- Shows state of all equipment in system
  - 1.3.6 Equipment Legend-Shows equipment color legend
- .1.4 Each graphic screen header shall contain the following: Date, Time, Main Navigation Button, Page Name, Login/Logout buttons, current logged in user, and page close button.
- .1.5 Graphic Display Names, Parameter Files, Alarm Names, Trend Templates, and Macros should all have a building number prefix as follows:
  - 1.5.1 McCracken – 069
  - 1.5.2 West Campus Substation – 134
  - 1.5.3 East Regional Chilled Water Plant – 376
  - 1.5.4 Central Power Plant Water Treatment Building – 390
  - 1.5.5 Smith Substation – 127
  - 1.5.6 Generator Building – 377
  - 1.5.7 South Campus Central Chilled Water Plant – 388
  - 1.5.8 OSU Substation – 079i.e.:



- .1.6 Key historical data shall be identified for each project. Data will be historicized in FactoryTalk SE Historian. Project A/E's will need to estimate the number of added points needed and insure each project provides licensing for the new points.
- .1.7 Trending shall be setup in FactoryTalk SE by each project utilizing the Historian. Trends will logically group data by system and avoid more than 8 pens per trend when practical. Trend Template names will use the building number prefix as shown above. One or more HMI screens will need to be created to provide pushbutton shortcuts to configured trends. Pushbuttons will be grouped logically per system.

.2 Local HMI's

- .2.1 Each control cabinet that contains a PLC shall be designed to have a local Panelview Plus 1500 touch connected to the PLC via Ethernet. The Panelview graphics shall match the graphics in Control Room FactoryTalk SE system. Graphics will need to update at 1-second intervals.
- .2.2 The Panelview alarm system shall match up with the FactoryTalk SE system alarms. There will be an Alarm Pop up with the latest alarm shown. An alarm history page is required. The Panelview will synchronize its time with the PLC once a day to maintain accurate alarm timestamps. Alarms acknowledged in the Control Room on the FTSE system should also remotely acknowledge alarms on the PanelView.
- .2.3 Security shall be configured on the Panelview as View Only, Operator Access, and Administrative Access. View Only access will only allow view of P&ID and overview screens, no control will be allowed from View Only access. Operator Access will allow the same control the operator has in the FTSE system. Administrative Access will allow full access to the Panelview, including Configuration. View Only access will be the default and will not require a password. The PanelView will be configured to automatically log out users after an inactive period of 45 minutes.

40 94 43 PROGRAMMABLE LOGIC PROCESS CONTROLLERS

.1 Integrator Qualifications and Certifications

- .1.1 Controls integrators shall be experienced in the I/O platform they are installing. Experienced is defined as being fully trained and having completed at least 3 other projects utilizing the I/O platform being installed. A fully trained integration engineer shall be onsite at all times when configuration, programming, and commissioning of the I/O platform is occurring. Non OEM integrators shall be



- members in good standing with the CSIA (Control System Integrators Association) and follow the CSIA's Best Practices and Benchmarks.
- .1.2 Any project that integrates controls into the Power Plant Boiler DCS (Honeywell Experion) shall use a Honeywell field service representative for programming, SCADA, and operator graphics. Integrators with experience with Honeywell Experion DCS may do their own integration into the Honeywell system if the engineer has attended the following Honeywell training courses:
    - 1.2.1 EXP02 Experion Server Engineering and Configuration
    - 1.2.2 EXP03 Experion Graphics Design and Building
    - 1.2.3 EXP20 Experion Control Execution Environment Controller
  - .1.3 The integrator shall also have their own licensed copy of Honeywell Experion for program development.
  - .1.4 Any project that integrates controls into the Utilities FactoryTalk Site Edition DCS shall use an integrator with FactoryTalk SE training for programming and implementation. Integrators are required to have the following ControlLogix/FactoryTalk SE training:
    - 1.4.1 CCP146 Studio 5000 Logix Designer Level 1: ControlLogix System Fundamentals
    - 1.4.2 CCP151 Studio 5000 Logix Designer Level 2: Basic Ladder Logic Programming
    - 1.4.3 CCP143 Studio 5000 Logix Designer Level 3: Project Development
    - 1.4.4 CCV207 FactoryTalk View SE Programming
    - 1.4.5 CCV204 FactoryTalk View ME and Panelview Plus Programming
  - .2 Plant Systems
    - .2.1 Boiler Steaming controls shall be specified as Rockwell ControlLogix controllers with redundant processors. All Analog I/O modules shall be HART compatible. Each ControlLogix controller shall have an Allen Bradley Panelview 1500 for local viewing and control of the boiler. The ControlLogix controller shall be integrated into the existing McCracken Ethernet network utilizing a 1756-EN2T card. The redundancy module should synchronize its internal clock to the PLC clock once a day to maintain accurate and synchronized time stamps of events.
    - .2.2 Boiler Burner Management Systems (BMS) shall be separate from the ControlLogix steaming controls. The BMS shall be Allen Bradley ControlLogix with an L61 Processor and redundant power supplies. Each BMS shall meet NFPA 85 standards. The BMS shall be integrated into the steaming controls via Ethernet. All permissive and interlock signals between the BMS and the steaming controls shall be hard wired 110 VAC digital inputs and outputs. The BMS shall have a local AB Panelview 1500 Operator Interface for burner control and monitoring. The BMS shall comply with NFPA 85 and all other applicable safety standards.
    - .2.3 Chiller, Cooling Tower, and Plant Auxiliary Equipment controls shall use AB Control Logix. Under no circumstances are OPC interfaces allowed to interface controllers to the FactoryTalk SE system. The selected controller shall communicate via Ethernet back to the FactoryTalk SE system.
    - .2.4 Remote plants shall use AB ControlLogix. Controllers shall be integrated into the

- .2.5 FactoryTalk SE system utilizing TCP/IP communications. Networking equipment shall be provided to utilize redundant fiber optic connections back to the McCracken Power Plant controls network. The remote plant shall be fully automated to both start/stop the remote system automatically or manually from the FactoryTalk SE system at the Power Plant.
- .3 Input/Output (I/O) Modules
  - .3.1 All I/O modules shall have DIN rail mounted remote termination panels and cables. Analog modules shall be HART protocol enabled if available from the OEM or OEM approved 3rd party modules.
- .4 Configuration Software
  - .4.1 If the Utilities Division does not possess the software to configure a new PLC or controller, 3 fully licensed copies of the software shall be specified to be provided with the project. Software shall be Windows 7 64-Bit Enterprise compatible. All software registration shall be transferred over to The Ohio State University.
  - .4.2 All software programs and content become the property of The Ohio State University. All modules within a software program shall be accessible by the University. All software programs shall be submitted free of any Non-Disclosure Agreements.
- .5 Spare Parts
  - .5.1 Each project shall provide one each of the following spare controller parts:
    - .5.1.1 Controller CPU
    - .5.1.2 Controller Backplane
    - .5.1.3 Controller communication module
    - .5.1.4 One of each type of I/O module
    - .5.1.5 One of each type of remote termination panel and cable
    - .5.1.6 One of each type of relay
    - .5.1.7 One of each type of power supply
    - .5.1.8 One of each type of redundancy module
- .6 Warranty and Technical Support
  - .6.1 Each controller shall be specified to be warranted for 2 years from the date of commissioning. The integrator shall provide a minimum of 2 years technical support for controller programming issues. If the project has provided a controller not made by Honeywell or Rockwell, 2 years of priority telephone technical support from the OEM shall be included as part of the project for controller issues.

40 96 41 PROGRAMMABLE LOGIC PROCESS CONTROLLER PROGRAMMING STANDARDS

PART 1 - Software Design

- .1 Control Coding Strategy: The following guidelines are intended to improve PLC operation, aid in the troubleshooting process, and help develop code that can be read and supported once the project is commissioned. They are not intended to inhibit the creativity of programmers. A control strategy is the sequence of steps that must occur

within the program to produce the desired output. When developing a control strategy, the programmer should always plan first and program later. The following guidelines should be used when implementing a control strategy.

- .1.1 Understand the desired functions of the system. This is accomplished by:
  - .1.1.1 Reviewing and understanding the Process and Instrumentation Diagrams.
  - .1.1.2 Reviewing and understanding SAMA diagrams.
  - .1.1.3 Reviewing and understanding any functional intent documents.
  - .1.1.4 Reviewing current plant operations with the OSU Automation and Operations team.
- .1.2 Review possible control methods.
- .1.3 Flowchart the process operation.
- .1.4 Translate the flowchart into PLC code.
- .2 The larger a project is, the more organization it will require. It is important to document the system throughout its development verses once it is installed. This can be accomplished by being well organized from start to finish.
  - .2.1 Flowcharting
    - .2.1.1 Flowcharting is just one of several techniques used when planning a program after a functional understanding of the process has been completed. Flowcharts should outline the operational process in a sequential manner. Each step in the chart should perform an operation. Flowcharts should never be long and complex. If a process is large and complex, a main flowchart should be developed that would indicate the major functions to be performed in the operation. Then several smaller flowcharts can be used to further describe each of the functions in the main flowchart. Flowcharts are the recommended technique because concepts and details, along with their relationship to each other are quickly clear. General descriptions of sequences and relationships that are difficult to breakdown also become obvious after applied to a flowchart. Finally, it is much easier to discuss and explain an operation to an end user in the form of a flow chart than in ladder logic. Once the process has been flowcharted, the programmer can start developing the ladder code based upon the flowcharts.
  - .2.2 Code Development
    - .2.2.1 Code development should not begin until an OSU Controls Engineer has reviewed and commented on the flow charts. All review comments shall be, documented, discussed, and agreed to by the programming team and the OSU Automation Team.
    - .2.2.2 Unless a process is extremely simple, it should be organized into modules or subroutines. The subroutines can then be ordered according to process flow. Before the actual code is started, each programmer should develop a method for assigning memory (addresses). The recommended method would be to use an excel

spreadsheet. The addresses should be grouped according to function. When assigning addresses, always leave enough room for future expansion. Always group addresses that are sent to an HMI together. This will help through-put of data between the PLC and the HMI. This memory map or address map should be included in the final documentation, for it could assist in troubleshooting and expansion of the control system. The code should be thoroughly documented. Each task or module should have comments describing the general operation. Abbreviations should be avoided if possible. When a description is too long, familiar abbreviations should be used. The following is a list of guidelines that should be followed for every control program.

- .2.2.2.1 Use flowcharts to develop your code
- .2.2.2.2 Organize code into functional modules
- .2.2.2.3 Order the code according to process flow
- .2.2.2.4 Develop a memory (address) map
- .2.2.2.5 Group all addresses according to functions
- .2.2.2.6 Always group addresses that are sent to an HMI
- .2.2.2.7 Document your code thoroughly
- .2.2.2.8 Avoid using abbreviations
- .2.2.2.9 Values that may need changed should always be coded as variables rather than hard coded constants
- .2.2.2.10 Avoid master control relays (MCRs)
- .2.2.2.11 The number of elements in a rung should be limited to what can be displayed on one screen of the programming terminal
- .2.2.2.12 Avoid the use of latching coils
- .2.2.2.13 Each module (subroutine) should have only one entry point, preferably from the main module
- .2.2.2.14 Modules (subroutines) should not call other modules
- .2.2.2.15 Avoid executing multiple messages at the same time by staggering them to execute on timer and the completion or error of the previous message.

### .2.3 General Code Formats

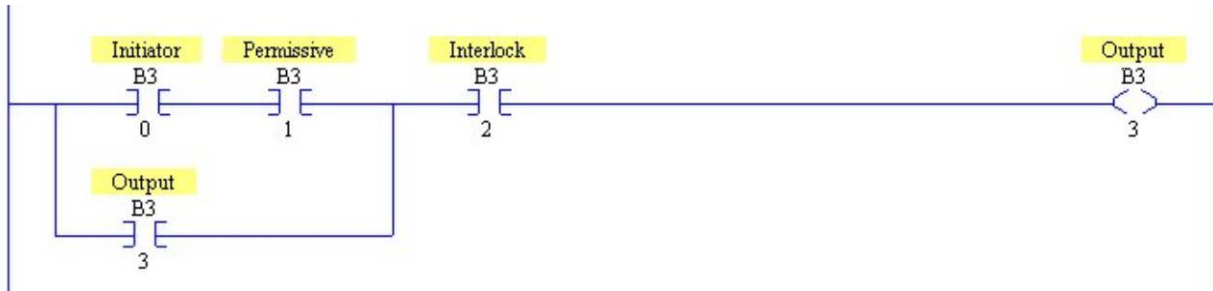
2.3.1 This section provides examples of general rung formats. The following terms will be used in the examples:

- Initiator – Starts or begins the rungs execution
- Permissive – Prevents the rung from initiating but will not drop it out.
- Interlock – Prevents the rung from initiating and will drop it out
- Seal-In – Seals in the output of the rung
- Output – The result of the rung execution

### 2.3.2 Guidelines

- .2.3.2.1 The initiator should always be the first element on the rung
- .2.3.2.2 The initiator should normally be momentary

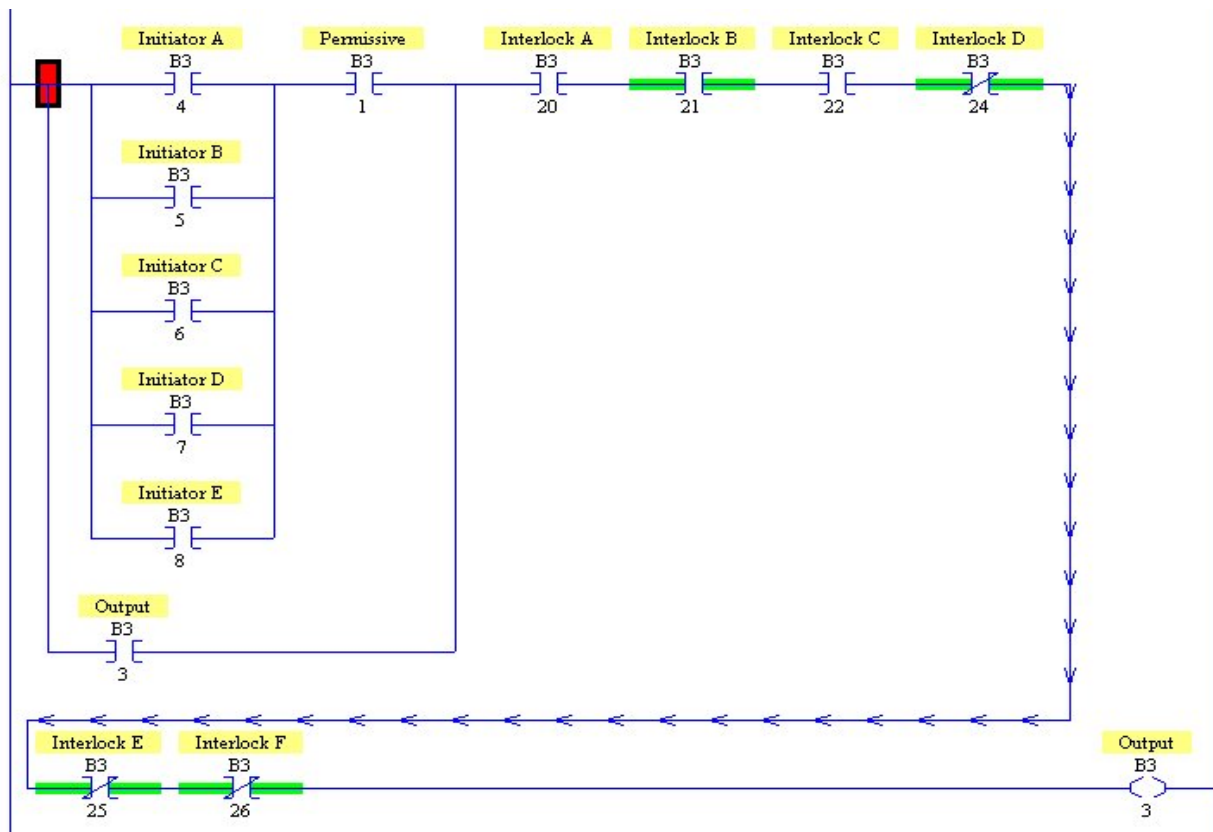
- .2.3.2.3 The permissive should be to the right of the initiator
- .2.3.2.4 Seal-Ins should be in parallel with the permissives
- .2.3.2.5 Interlocks should follow the permissives and go before the output



**Figure 1.1 - General Rung**

Figures 1.2, 1.3, and 1.4 - General Large Rungs

Avoid programming rungs that contain too many elements. Simplify the rung by dividing it into separate components. Figure 1-2 shows a rung with multiple elements. Figures 1-3 and 1-4 show the equivalent logic, but simplified.



**Figure 1.2**



Figure 1.3

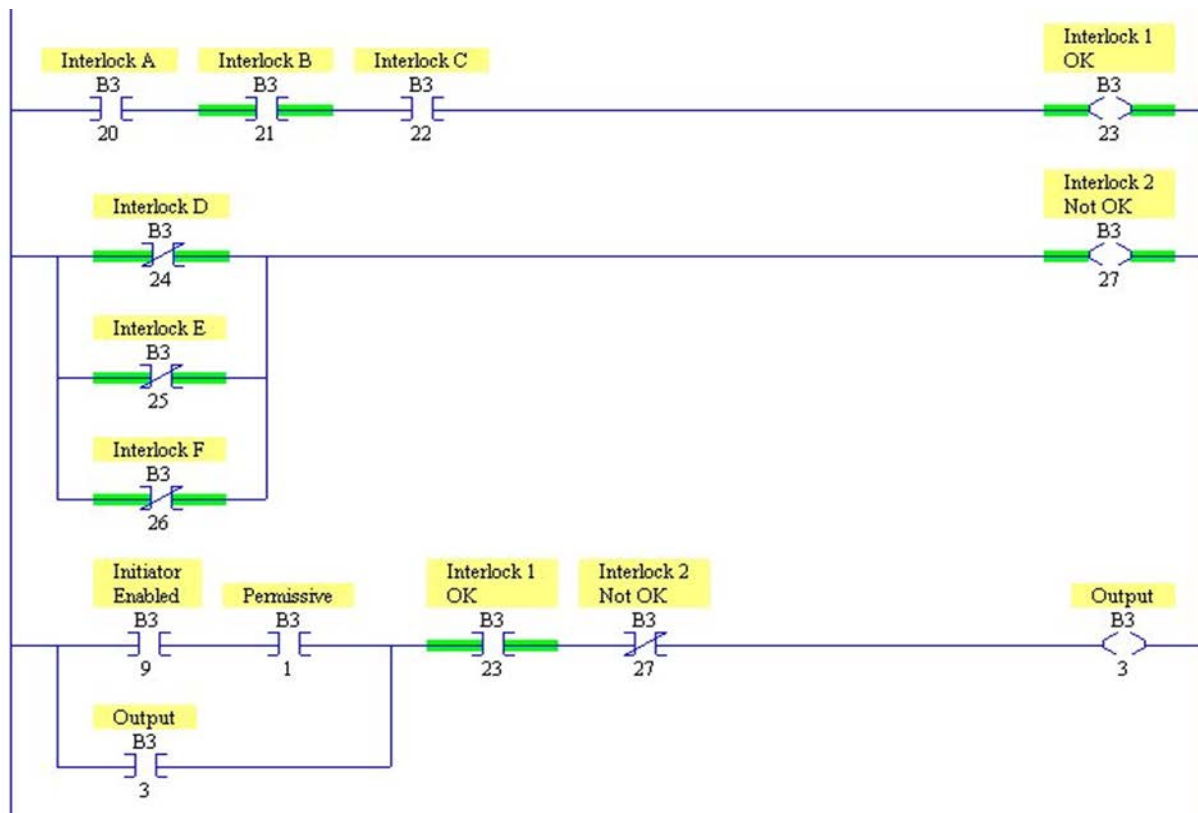


Figure 1.4

- .3 Documentation - Documentation is a critical part of any PLC program. To make a program readable to the end user and other engineers in the organization, all programmers should make full use of the programming software's documentation capability. If a program is documented well, the troubleshooting process time can be greatly reduced.
- .3.1 Descriptors - Every address in a PLC program shall have a unique descriptor associated to it. Input and Output descriptors should contain information that indicates physical location, device/equipment type and functional meaning. Symbols should match the device identification tag found on the electrical drawing I/O schematics.
- .3.1.1 Inputs will always start with physical location followed by equipment type and functional meaning.  
Input Example:  
Physical Location North, Lower, Operator Pedestal, etc.  
Equipment type Conveyor, Motor, Reservoir, etc.  
Functional Meaning Start, Stop, Forward, Reverse, Low Level, etc.  
Symbol 112PB, 4533LS
- .3.1.2 Outputs will always start with functional meaning followed by physical location and equipment type.  
Output Example:  
Functional Meaning Start, Stop, Open, Close, etc.  
Physical Location North, Prefill, etc.  
Equipment type Conveyor, Motor, Valve, etc.  
Symbol 112MS, 4533SOL
- .3.1.3 Internal coils will not be in a specific order. Use as much information as possible to describe the use of the internal coil.  
Internal Coil Example #1: Internal Coil Example #2:  
North Autopurge  
Furnace Step 1  
Over Temperature "Vacuum to  
Alarm 1 Torr"
- .3.1.4 Internal addresses that interface with a HMI should always contain either of the phrase's "From HMI" or "To HMI" as the last line of their descriptor.  
Internal HMI Example #1: Internal HMI Example #2:  
North Processing  
Fluid Pump Tank 321  
Start Temperature  
Pushbutton Set point  
From HMI From HMI
- .3.1.5 All I/O descriptors should be named for the true (On State) condition of the input or output. If an I/O point does not represent a true condition,

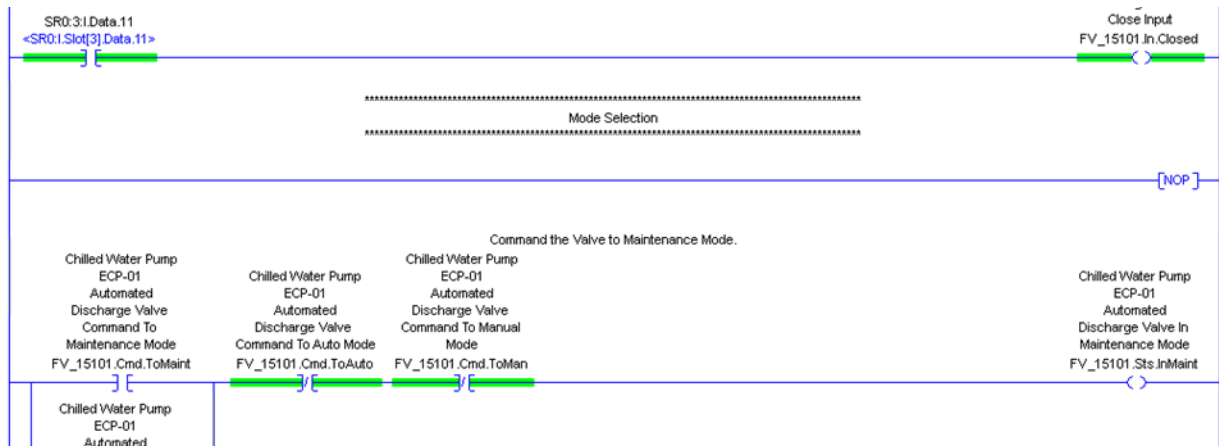
fail safe devices, the descriptor shall contain “Normally Closed” in the description.

Input Example:

Physical Location	North
Equipment type	Reservoir
Functional Meaning	Low Low Level
	Normally Closed
Symbol	423LVS

In the example above, the input would be on when the level is ok and off when the level goes low. This is a common fail safe situation that would be tied to a pump that would be pumping out of the tank. If the wire is cut or the device fails, the logic would stop a pump from emptying a tank and possible damaging the pump.

- .4 Symbols - Symbols are to be used for all Input and Output address only. Symbols can be added to integer or floating point addresses only if the address comes from the BTR or BTW of an analog module.
- .5 Rung Comments - Rung Comments should be used to further describe a rung or a group of rungs. It is up to the programmer to decide where to use rung comments. As a rule of thumb, if a rung or group of rungs would benefit from further description than the descriptor provides, a rung comment is required. If using a rung to segment a routine into logical sections for troubleshooting purposes, use the NOP instruction instead of an OTE.



- .6 Page Titles - Page titles should be used to summarize and identify the operation and functionality of the code that is below the title.

PART 2 - PLC Tag Structure and Naming

- .1 User Defined Tag Group - A UDT is a data structure defined by the programmer. A user-defined data type groups different types of data into a single named entity. Like tags,



the members have a name and data type. A UDT is usually used when there is multiple equipment of the same type. A tag is created for each piece of similar equipment with its type being the same UDT. This allows for a common tag structure to be used for all similar equipment. The following are examples of UDT names that were used for a Chiller project.

- Chiller
- TowerMCC
- TowerVFD
- CondWaterPump
- ChillWaterPump

.2 Tag Naming Convention - The tag names that will be created in the OSU Chiller Control System PLC software will follow the convention described below. This convention allows tags to be logically organized and facilitates troubleshooting and maintenance of the application. Each tag name will be made up of several fields. These fields when put together will identify the equipment and describe the tags use. These fields will include either a group or single piece of equipment’s identification; an attribute identifier of the equipment and a description of the attribute that further defines its function. This naming convention will be used for tags within a UDT as well as standalone tags.

.2.1 Creating Tag Names - In order to create a tag, you will need to identify and define several items. The first step in creating tags is to organizing the equipment into functional groups. When grouping equipment, try and group equipment that operates as a self-contained system. After a group of equipment is defined it should be assigned an abbreviation that will be used as part of the tag name. Note that only groups that have long descriptions will be abbreviated. Each group of equipment will then be assigned a UDT type. For example, based on the P&ID drawing of the OSU Chillers 8-10, the following groups of equipment can be defined:

Equipment Group Description	Equipment Group Abbreviated Identification	UDT Type
Chiller #8	Chiller8	Chiller
Chiller #9	Chiller9	Chiller
Chiller #10	Chiller10	Chiller
Tower #14	Tower14	TowerMCC
Tower #15	Tower15	TowerVFD
Tower #16	Tower16	TowerMCC
Tower #17	Tower17	TowerVFD
Tower #18	Tower18	TowerMCC
Tower #19	Tower19	TowerVFD
Chilled Water Pump 10	ChilledPump10	ChillWaterPump
Chilled Water Pump 11	ChilledPump11	ChillWaterPump
Chilled Water Pump 12	ChilledPump12	ChillWaterPump
Chilled Water Pump 13	ChilledPump13	ChillWaterPump
Condenser Water Pump 10	CondenserPump10	CondWaterPump

Condenser Water Pump 11	CondenserPump11	CondWaterPump
Condenser Water Pump 12	CondenserPump12	CondWaterPump
Condenser Water Pump 13	CondenserPump13	CondWaterPump

.2.2 Once the different groups of equipment are defined, each piece of equipment that is part of a group should be identified. When identifying this equipment, the P&ID instrument identification tag number should be recorded. This identification number will be used in the tag name to identify the equipment. For example Chiller #8 has the following devices:

Equipment Description	Instrument Identification Tag Number
Chiller #8 Chilled Water Flow Present	HS-CH0850
Chiller #8 Chilled Water Inlet Temperature	TIT-CH0801
Chiller #8 Chilled Water Outlet Temperature	TIT-CH0802
Chiller #8 Tower Water Inlet Temperature	TIT-CH0803
Chiller #8 Tower Water Outlet Temperature	TIT-CH0804
Chiller #8 Chilled Water Flow	FIT-CH0801

.2.3 After all of the equipment has been grouped and identified, the functionality of the equipment should be identified and recorded. Note that a group of equipment can perform a function as well as a single piece of equipment that is used as part of a group. Below are some sample functions for Chiller #8.

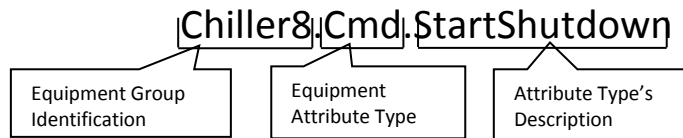
- Start Chiller #8 Shutdown Cycle
- Start Chiller #8 Primary Compressor
- Start Chiller #8 Lag Compressor

.2.4 Finally, before a tag name can be put together, you will need to define the attributes that will be used to characterize the group or single piece of equipment. There are four different categories of attributes that can be used to characterize equipment. The first type of attribute is commands. Commands are used to initiate a function. Typical commands are Start, Stop, Open and Close. All commands will be prefixed with the abbreviation of “Cmd”. The second type of attribute is settings. Settings are modifiable variables that are used to control the equipment. Typical settings are set points and alarm limits. All settings will be prefixed with the abbreviation of “Set”. The third type of attribute is values. Values are used to represent an assigned or computed varying quantity. Typical values are temperatures, pressures and flow totals. All values will be prefixed with the abbreviation of “Val”. The fourth type of attribute is statuses. Statuses are used to represent the state or condition of an object. Typical Statuses are opened, closed, and running. All statuses will be prefixed with the abbreviation of “Sts”. Below is a table that summarizes the attributes that are used to characterize equipment.

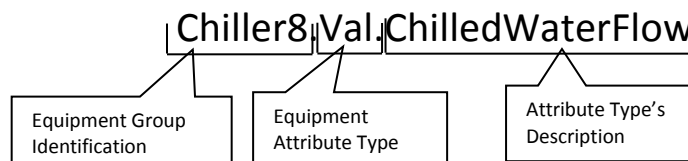
Category	Prefix Abbreviation	Description	Examples
Commands	Cmd	Commands are used to initiate a function.	Start, Stop, Open, Close
Values	Val	Values are used to represent an assigned or computed varying quantity.	Temperatures, Pressures, Flow Totals
Settings	Set	Settings are modifiable variables that are used to control the object.	Set points, Alarm Limits
Statuses	Sts	Statuses are used to represent the state or condition of an object.	Running, Stopped, Opened, Closed

.2.5 Once all of the items above have been completed, you can put them together to form a descriptive tag name. The following diagrams show the location\order of the fields that make up a tag name.

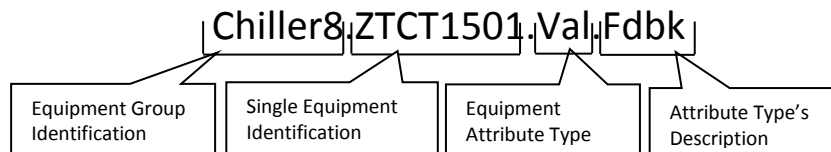
Example of a tag name associated with a group of equipment not part of a UDT:



Example of a tag name associated with a group of equipment inside a UDT:



Example of a tag name associated with a single piece of equipment:



.2.6 The following items summarize the tag naming convention:

- .2.6.1 Tag Names should be organized by grouping equipment based on area and function.
- .2.6.2 Use one of the 4 standard attribute types to further define a tag.
- .2.6.3 The first letter of every word should be capitalized.
- .2.6.4 Spaces should never be used between words.
- .2.6.5 Underscores should only be used between words when upper and lower case text cannot be used.
- .2.6.6 When using abbreviations, the same abbreviation shall be used throughout the application and come from the approved abbreviation table.

.2.6.7 Tag names should be kept as short as possible to minimize controller memory usage.

**Table of Abbreviations**

Word	Abbreviation	Word	Abbreviation	Word	Abbreviation
Abort	Abrt	Engine	Engn	Pallet	Pal
Aborted	Abtrd	Enter	Entr	Parameter	Param
Accept	Acpt	Error	Err	Position	Pos
Acknowledge	Ack	Exhaust	Exh	Present	Prsnt
Address	Addr	Extend	Ext	Pressed	Prsd
Advance	Adv	Extended	Extd	Pressure	Prsr
Advanced	Advd	Fault	Flt	Process Variable	PV
Advancing	Advq	Feedback	Fdbk	Program	Pgm
Alarm	Alm	Float Switch	Fls	Proof	Prf
Assembly	Assy	Forward	Fwd	Proximity Switch	Prox
Automatic	Auto	Frequency	Freq	Pulse	Pls
Backup	Bkup	Green	Grn	Pushbutton	PB
Block	Blk	Hold	Hld	Raise	Rais
Blocked	Blkd	Horizontal	Horiz	Raised	Raisd
Blue	Blu	Human Machine Interface	HMI	Raising	Raisg
Build	Bld	Immediate	Imed	Ready	Rdy
Calibration	Calib	Input	In	Receive	Rcv
Change	Chng	Interlock	Intlk	Recover	Rcvr
Check	Chk	Leaving	Levg	Reject	Rej
Circuit Breaker	CB	Level	Lvl	Retract	Retr
Clamp	Clmp	Light	Lt	Retracted	Retrd
Clamped	Clmpd	Light Curtain	LtCurt	Return	Ret
Clear	Clr	Limit Switch	LS	Reverse	Rev
Close	Clc	Load	Ld	Rotate	Rot
Closed	Clcd	Lookup	Lkup	Select	Sel
Closing	Clsg	Lower	Lwr	Selector Switch	SS
Command	Cmd	Lowered	Lowrd	Sequence	Seq
Communication	Comm	Lowering	Lowrg	Setpoint	SP
Complete	Cmplt	Machine	Mach	Slide	Sld
Completed	Cmpltd	Maintenance	Maint	Starved	Strvd
Connected	Cnctd	Manifold	Mnfld	Station	Sta
Control	Ctrl	Manual	Man	Status	Sts
Control Variable	CV	Memory	Mem	String	Str
Conveyor	Conv	Message	Msg	Target	Tgt

Word	Abbreviation	Word	Abbreviation	Word	Abbreviation
Counter	Ctr	Motion	Motn	Temperature	Temp
Cycle	Cyc	Motor	Mtr	Text	Txt
Cylinder	Cyl	Normal	Nrml	Timeout	TOut
Deadband	DB				
Delay	Dly	Number	Num	Unload	Unld
Diagnostic	Diag	Okay	OK	Vacuum	Vac
Done	Dn	Opened	Opnd	Vertical	Vert
Downstream	Dnstrm	Opening	Opng	Warning	Wrn
Emergency	Emerg	Operator	Oprtr	Water	Wtr
Emergency Stop	E-stop	Output	Out	Write	Wrt
Enable	Enbl	Overtravel	OTrvl		

**PART 3 - Alarming**

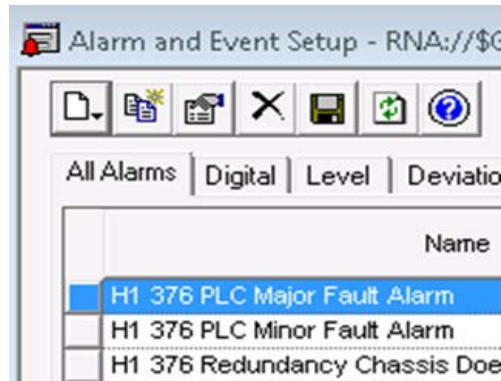
.1 Alarm Rationalization - An alarm rationalization process is required of all projects with HMI's that have operator interaction. Any alarm that an operator will see will require the operator to take an action. Alarm actions shall be documented with Operations and Procedure manual for the system being installed. Alarms that do not require operator action are defined as events and should never be on an alarm screen.

.1.1 All Alarm Names shall have the prefix of the building number as outlined in section 40 94 33.1.5

.1.2 Alarms will have 4 priorities:

- Urgent
  - Operator must respond in 60 seconds or less.
  - Level should only be used for Life-Safety, equipment protection, or equipment shutdown. Example: High High Water level in a boiler.
  - FactoryTalk Alarm and Event Priority: 1000.
- High
  - Operator must respond in 2 minutes or less.
  - Level should be used to warn of an impending Urgent alarm or to escalate a Low priority alarm. Example: High water level alarm in a boiler.
  - FactoryTalk Alarm and Event Priority: 750.
- Low
  - Operator response can be greater than 2 minutes.
  - Level can be used by itself or as a predecessor to High level alarm. Example: High conductivity in a boiler.
  - FactoryTalk Alarm and Event Priority: 250.
- Diagnostic
  - PLC diagnostic alarms. Example: PLC Major Fault.
  - Level is not seen by operator on alarm screen but an HMI page should show the fault. Diagnostic alarms are emailed to the Plant Automation shop via WIN-911FactoryTalk Alarm and Event Priority: 1

- Diagnostic items shall have a special prefix of “H1” in the Alarm Name and use the format: H1 [Building Number] [Alarm Name]
  - i.e.: H1 376 PLC Major Fault Alarm



.1.3 The percentage of alarms per priority should be:

- Urgent <5%
- High <15%
- Low <=80%

.2 Alarm Acknowledgment

.2.1 The Alarm routine shall utilize a single bit from the FactoryTalk SE or Honeywell Experion system to acknowledge and reset alarms per the example below, Figure 3.1. Examples on how to code alarms in the PLC, Figures 3.2 and 3.3.

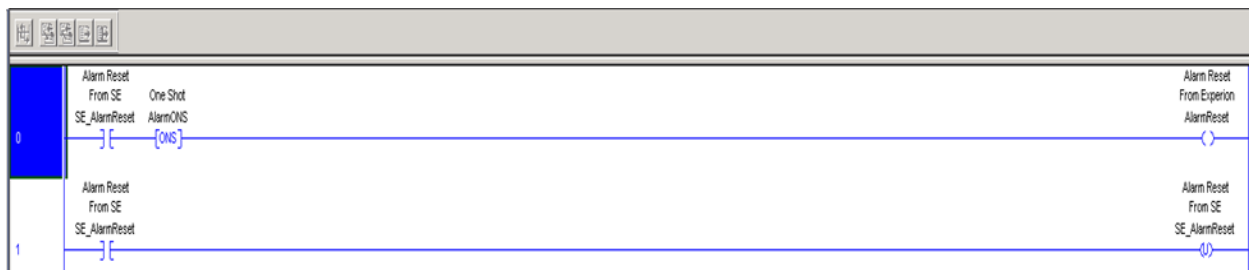
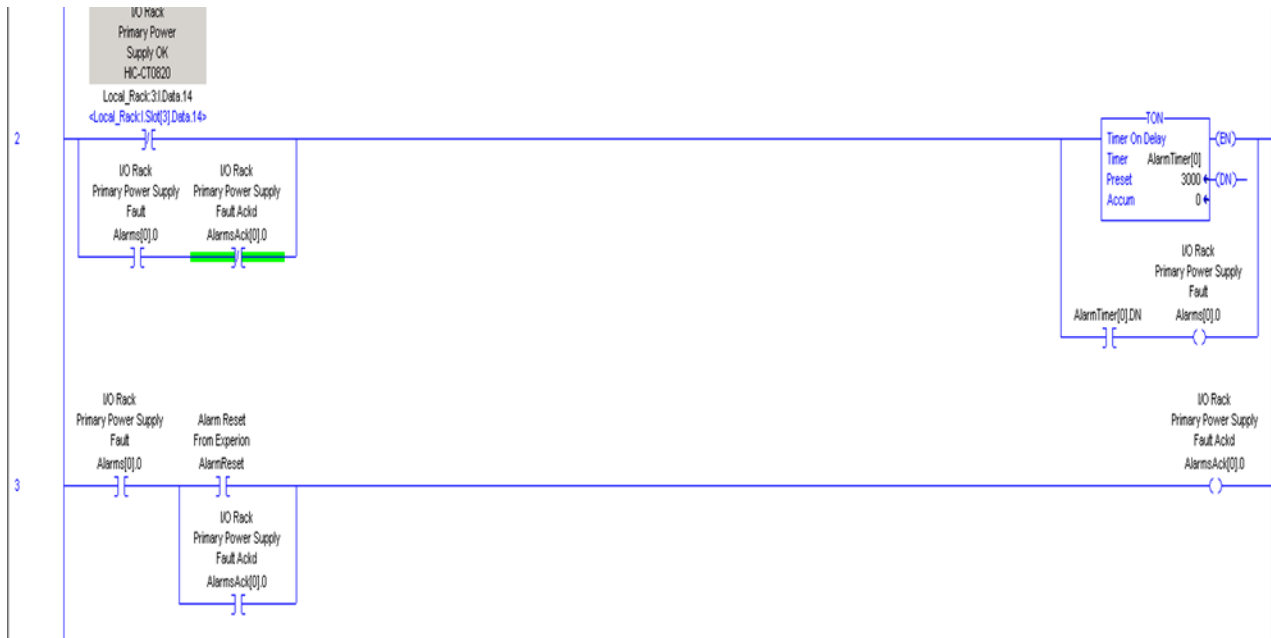
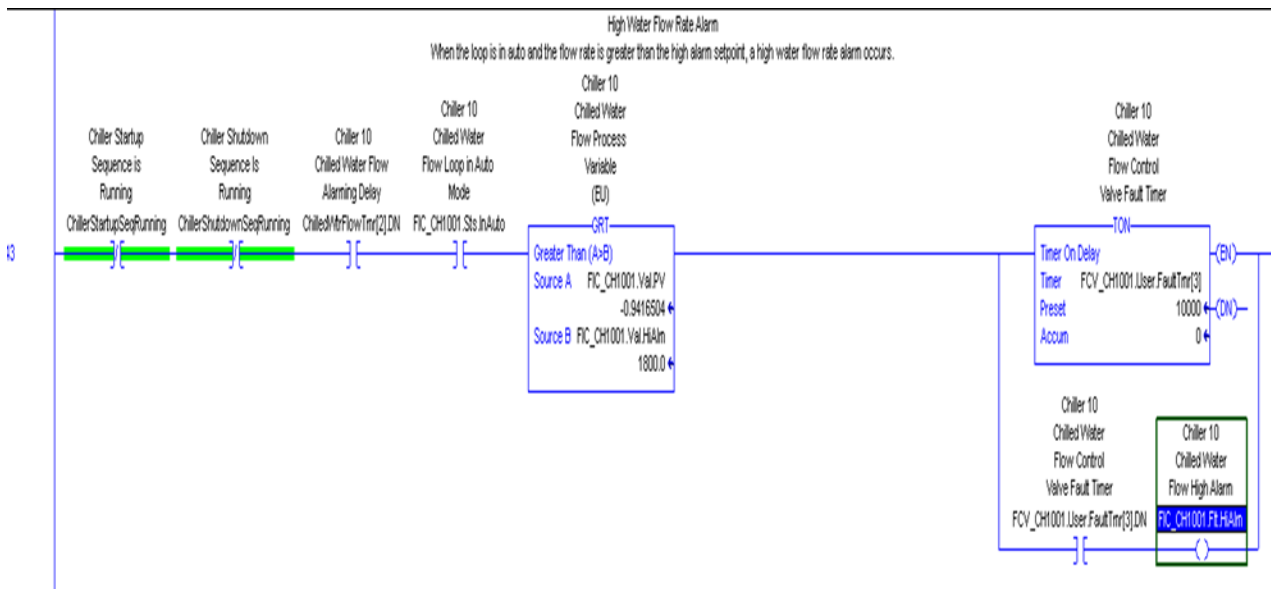


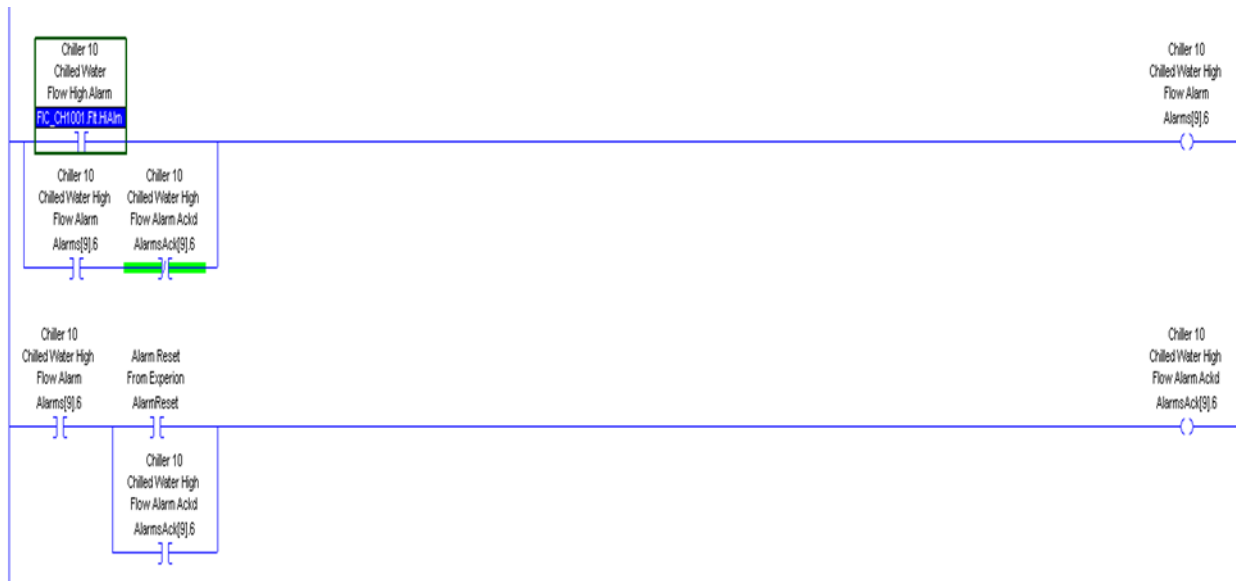
Figure 3.1



**Figure 3.2**  
**Example of a Digital alarm with acknowledge rung**



**Figure 3.3 (cont. see below)**  
**Example of an analog level alarm with acknowledge rung**



#### PART 4 – Fault routines

- .1 The following fault routines are required of every Rockwell PLC project:
  - .1.1 Controller fault handler-Alarm mapped to HMI server
  - .1.2 ControlNet media status for the A and B channel
  - .1.3 Ethernet Ring Fault (if used)
  - .1.4 Local Rack Communication fault
  - .1.5 Remote Rack Communication fault
  - .1.6 VFD Communication fault
  - .1.7 PLC Minor fault alarm

#### PART 5 - Data mapping/Totalizers

- .1 Projects connecting to the boiler-side Experion system will need to map Rockwell PLC data tags to PLC 5 tags using RSLogix 5000. Real number values will need to be mapped to F registers. Boolean values will need to be mapped to N registers. PLC programmer shall provide a spreadsheet of the data mapping for the HMI programmer with register, data description, and range value of the data if it is an analog or calculated point.
- .2 Boiler PLCs will totalize the following data points utilizing the totalizer function block in RSLogix 5000:
  - .2.1 Gas flow
  - .2.2 Oil Flow
  - .2.3 Steam Flow
  - .2.4 Feedwater flow
- .3 Chiller PLCs will totalize the following data points utilizing the totalizer function block in RSLogix 5000:
  - .3.1 Chiller Tonnage
  - .3.2 Tower Makeup Flow



- .3.3 Tower Blowdown Flow
- .3.4 Chilled Water loop Makeup flow
  
- .4 Totalizers shall be programmed to reset daily at 12:01 AM.

PART 6 - Programming software

- .1 Projects shall be developed in Rockwell RSLogix 5000 software, version 20.1 or greater. Panelview HMI programs shall be developed in the latest version of software available during the controls engineering phase of the project.

40 95 00 PROCESS CONTROL HARDWARE

Specify that process control hardware shall be industrial grade and able to withstand temperatures between 32 and 160°F.

40 95 13 PROCESS CONTROL PANELS AND HARDWARE

.1 Control Panels

- .1.1 The A/E shall specify that all control panels shall be NEMA 12. In areas where there is a likelihood of water splashing on the panel, the panel shall be specified to be NEMA 4X. Panels shall be specified to have a built in hasp to allow locking with a padlock. Panels shall also be provided with an external Ethernet port and 3 amp electrical socket that can be secured via a padlock.
- .1.2 The A/E shall specify and design for all conduit and tray entry into control panels to be from the bottom or side. Top penetrations are not allowed.

.2 Panel Hardware

- .2.1 The A/E shall design all control panels to be equipped with an isolated copper bus bar to connect to the plant instrument grounding system. This is separate from the panel safety ground. The bar shall be sized to accept a 4-0 grounding cable from the field. All IFM shield grounds shall be wired to the instrument ground bus bar.

.3 Panel wiring

- .3.1 All wiring inside the panel going to compression type terminals shall be specified to have ferrules installed at the terminal. If ferruling is not practical, all wires shall be specified to be tinned at the termination. All panel and wiring shall be specified to be labeled per the Termination Drawings.
  
- .3.2 Wire colors shall be as follows:

120 VAC HOT	Red
120 Neutral	White
24 VDC +	Blue
24 VDC Common	White w/ Blue Stripe
Instrument Ground	Green w/ Yellow Stripe
Safety Ground	Green

.3.3 Low power signal and communication wires should not run in the same cable raceway as control and AC power. Separate as much as possible and avoid parallel runs.

.4 Panel Design

.4.1 Panels shall be designed to accept redundant UPS power feeds for 120 VAC power. Power above 120 VAC is prohibited inside a control panel. Incoming power feeds shall be labeled and have lockable circuit breakers inside the control panel to isolate power.

.4.2 Panels shall be sized to dissipate heat loads inside the panel with ambient exterior temperatures at 104°F. PLC CPU's shall be designed to be installed in the bottom 1/3 of the panel.

40 95 23 PROCESS CONTROL INPUT/OUTPUT MODULES

.1 Rockwell 1756 I/O modules

.1.1 1756 series I/O modules shall use 1492 Interface Modules (IFM) for field-side wiring. Digital/Analog input and Digital Output IFMs shall be fused. Digital outputs controlling electric motors with a starter larger than NEMA Size 1 shall have an interposing relay between the digital output and the motor starter. Wiring to IFMs shall follow Rockwell's Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.

.1.2 Analog input I/O modules shall be 4-20 mA, HART modules. 1756-IF8H or 1756-IF16H shall be used.

.1.3 Analog output I/O modules shall be 4-20 mA, HART modules. 1756-OF8H shall be used.

.1.4 Digital input and output modules shall be either 120 VAC or 24 VDC, depending on the application. 24 VDC shall not be used in any safety system application. Cards should be the isolated type with no more than 16 points per card.

.2 Honeywell C200 modules

.2.1 Except for specialty cards, such as Modbus interfaces, the Honeywell C200 shall use the same 1756 I/O cards as in Section .1 above. I/O cards shall be purchased from Honeywell due to firmware issues. IFMs can be purchased from Rockwell directly. Module requirements and wiring guidelines are the same as in Section .1 above.

.3 1769 Compact Logix I/O modules

.3.1 1769 series I/O modules shall use 1492 Interface Modules (IFM) for field-side wiring. Digital/Analog input and Digital Output IFMs shall be fused. Digital outputs controlling electric motors with a starter larger than NEMA Size 1 shall have an interposing relay between the digital output and the motor starter. Wiring to IFMs shall follow Rockwell's Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.

.3.2 Analog input I/O modules shall be 4-20 ma, HART modules. 1769sc-IF4IH shall be used.

- .3.3 Analog output I/O modules shall be 4-20 ma, HART modules. 1769sc-OF4IH shall be used.
- .3.4 Digital input and output modules shall be either 120 VAC or 24 VDC, depending on the application. 24 VDC shall not be used in any safety system application. Cards should be the isolated type with no more than 16 points per card.

40 95 26 PROCESS CONTROL INSTRUMENT AIR PIPING AND DEVICES

.1 Instrument Air Lines

- .1.1 The A/E shall design and specify that the initial horizontal run shall be a minimum half inch diameter line (with root valve) terminating with a plugged tee and having drop lines from it, unless otherwise shown, sizes as follows:

Number of instruments supplied from one branch line	Branch line size
2 or less	1/4" NPS Pipe or 3/8" OD Tube
5 or less	3/8" NPS Pipe or 1/2" OD Tube
15 or less	1/2" NPS Pipe or 5/8" OD Tube
Over 15	1" NPS Pipe or 1-1/8" OD Tube

Number of control valves supplied from one branch line	Branch line size
1	1/4" NPS Pipe or 3/8" OD Tube
2	3/8" NPS Pipe or 1/2" OD Tube
4	1/2" NPS Pipe or 5/8" OD Tube
more than 4	1" NPS Pipe or 1-1/8" OD Tube

- .1.2 Instrument air sub-headers from root valves to individual supplies 1 inch and greater shall be designed by the A/E per OSU Utilities requirements. All control tubing 7/8-inch and smaller shall be in accordance with .2 CONTROL TUBING specified below in this Section.
- .1.3 Branch lines shall be connected to the supply headers at the top of the pipe.
- .1.4 Individual air filters, air pressure reducing valves with built in relief valve, and 2-inch diameter pressure gauges shall be supplied by the Contractor for each instrument.
- .1.5 Main and branch air supply headers shall have blowdown lines and valves at every low point, with a minimum of one blowdown per building elevation. These are to be 1/2-inch nominal pipe with gate valves 48-inches above the floor.

.2 Control tubing

- .2.1 All tubing shall be seamless, fully annealed, stainless steel tubing conforming to ASTM A 269, Grade TP 316. The ends shall be plugged before shipment.
- .2.2 Fittings shall be flareless compression Type 316 stainless steel. Approved fittings are as follows:
  - CPI by Park-Hannifin
  - SWAGELOK by Swagelock

- TYLOK by Tylok International

- .3 Instrument air  
.3.1 Instruments air is defined as compressed air free from contaminants that has a dew point of -40°F.

40 95 33 PROCESS CONTROL NETWORKS

- .1 Prior to installing new network equipment, an engineering study shall be completed by the Project's A/E to determine the data load and security impacts of the new networking equipment. The person performing the study shall be Network ++ certified or have an equivalent certificate. Study shall encompass the full controls network with special attention paid to multicasting control (IGMP snooping), vLANing, network loading, ACLs, ring redundancy, firewalling, DMZ's, and routing. Project A/E's study recommendations shall be included in the installing contractor's scope for the project.

- .2 The A/E shall specify that Contractors will not be allowed to have direct access to the Utilities network with laptops or any other device. Utilities will provide a laptop when needed for project work. All contractor produced files that are to be used on the Utilities network will be uploaded to a Box account, downloaded by Utilities personnel, and scanned for viruses on a computer that is not on the Controls Network. Limited remote access is available to the Utilities network for technical support. Remote access will not be used for checkout, startup, or commissioning activities. The A/E and Contractors shall refer to the Utilities Remote Network Access Policy for more information.

.3 Cabled Process Control Network

- .3.1 Specify that Ethernet cables shall be CAT6 Shielded Industrial with the following properties:

- .3.1.1 Industrial grade PVC outer jacket
- .3.1.2 Aluminum foil-Polyester Tape shield, 100% coverage with drain wire
- .3.1.3 PVC Inner Jacket
- .3.1.4 23 AWG solid copper conductors with polypropylene insulation

- .3.2 Approved cable: Belden Data Tuff 7953A

- .3.3 Cables shall be terminated with a shielded, CAT6 compatible RJ-45 plug on one end only. This end will be the switch end. In the situation where the cable is going from switch to switch, one switch shall have the terminated shield only. The shield drain wire shall be properly installed in this plug. The other end shall be terminated with a standard, CAT6 compatible RJ-45 plug. This end will NOT have the shield terminated. All cables ends shall have proper strain relief devices installed. Cables shall be tested with a Fluke DSX-5000 Cable Analyzer or approved equal. Specify that the contractor shall provide full report on cable testing to the A/E and University.

.4 Fiber Optic Process Control Network

.4.1 OPTICAL FIBER CABLE

- .4.1.1 Description: Single mode, 9/125-micrometer, 12-fiber, nonconductive, tight buffer, optical fiber cable. Cable shall be Corning Freedom cable.

- .4.1.1.1 Comply with ICEA S-83-596 for mechanical properties.
- .4.1.1.2 Comply with TIA/EIA-568-B.3 for performance specifications.
- .4.1.1.3 Comply with TIA/EIA-492AAAA-B for detailed specifications.
  - .4.1.1.3.1 Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
- .4.1.1.2 Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
- .4.1.1.3 Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

.4.1.2 Jacket:

- .4.1.2.1 Jacket Color: Aqua for 9/125-micrometer cable
- .4.1.2.2 Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B
- .4.1.2.3 Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

.4.2 OPTICAL FIBER CABLE HARDWARE

- .4.2.1 Cable Connecting Hardware: Comply with the Fiber Optic Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
  - .4.2.1.1 Quick-connect, simplex and duplex, Type SC and Type ST connectors. Insertion loss not more than 0.75 dB.
- .4.2.2 Approved Manufacturers: Corning Cable Systems InfiniCor SX+ Optical Fiber Cabling, Termination Components, and Enclosures.

.5 Wireless Process Control Network

- .5.1 No wireless devices of any kind shall be designed, installed, or allowed access on the process control network.

40 95 49 PROCESS CONTROL ROUTERS AND FIREWALLS

- .1 Routers shall be redundant with high availability features that will automatically roll over to the backup router on fault or failure. Router shall be designed to be fed from separate UPS power feeds. Current uplink to the building network uplink is CAT 6 cable with a 1 GB speed. Router shall be capable of routing both public and private IP addresses. Router shall have built in VPN capabilities. Device chosen may be a firewall/router combination device. Device shall be approved by the University's OCIO office as supportable device. Device shall be provided with a 5-year renewable 24/7 support contract.
  - .1.1 Approved Model, specify Dell NSA 3600.
- .2 Firewalls shall be a robust model capable of deep packed inspection without degradation of the 1 GB network throughput. Firewall shall be redundant with high availability features that will automatically roll over to redundant firewall on fault or

failure. Firewall shall be designed to be on separate UPS electrical feeds. The following features shall be included in the firewall:

- .2.1 Gateway Antivirus
- .2.2 Anti-spyware
- .2.3 Intrusion Prevention
- .2.4 Botnet Prevention
- .2.5 App Control
- .2.6 Content filtering
- .2.7 SYN flood protection
- .2.8 Multicast Snooping
- .2.9 Remote log file storage
- .2.10 Alert messaging via email

- .3 Device chosen may be a firewall/router combination device. Device shall be approved by the University's OCIO office as supportable device. Device shall be provided with a 5-year renewable 24/7 support contract.

- .3.1 Approved Model, specify Dell NSA 3600.

#### 40 95 53 PROCESS CONTROL SWITCHES

- .1 Control Cabinet Networking Equipment:

- .1.1 Industrial Managed Ethernet switch, software Layer 2 Basic, store and forward switching mode 10Mbit/s and 100Mbit/s; Shall be capable of using VLANs, IGMP snooping, https, and ring redundancy.
- .1.2 Ports: 10/100BASE-TX RJ-45 ports, auto-crossing, auto-negotiation, auto polarity, 8 ports minimum
- .1.3 Voltage: 24 VDC
- .1.4 Operating Temperature: 0 to 60°C with a fanless housing
- .1.5 Relative Humidity: 10% to 95% (non-condensing)
- .1.6 Mounting: 35 mm DIN rail
- .1.7 Metal case, IP20 rated
- .1.8 Line/star/ring topology
- .1.9 Diagnostic LEDs
- .1.10 Redundant 24 Vdc power with plug-in terminal block
- .1.11 Manufacturer, specify Hirschmann (RS20-0800T1T1SDABHH05.0)

- .2 Rack-Mounted Ethernet Networking Equipment:

- .2.1 Industrial Managed Ethernet switch, software Layer 2 Basic, store and forward switching mode 10Mbit/s, 100Mbit/s, and 1000Mbit/s; Shall be capable of using VLANs, IGMP snooping, https, and ring redundancy.
- .2.2 Ports: 20/1000BASE-TX RJ-45 ports, auto-crossing, auto-negotiation, auto polarity, 8 ports minimum. 4/1000BASE-TX single-mode fiber ports, auto-crossing, auto-negotiation, auto polarity
- .2.3 Voltage: 120 VAC
- .2.4 Operating Temperature: 0 to 60°C with a fanless housing
- .2.5 Relative Humidity: 10% to 95% (non-condensing)
- .2.6 Mounting: Standard Rack mounting

- .2.7 Metal case, IP20 rated
- .2.8 Line/star/ring topology
- .2.9 Diagnostic LEDs
- .2.10 Redundant 120 VAC power with plug-in terminal blocks
- .2.11 Manufacturer, specify Hirschmann (MACH104-20TX-FR)

40 95 73 PROCESS CONTROL WIRING

.1 Process Control Cable

- .1.1 Instrumentation Analog Signal Cable shall be No. 18 AWG stranded, tinned copper conductors, polyethylene insulation, twisted pair, 100% coverage aluminum polyester shield, No. 20 AWG stranded, tinned copper drain wire with vinyl outer jacket, UL Listed rated for 300V indoors, above grade, or inside control panels.
  - .1.1.1 Approved Cable, specify Belden 8760.
- .1.2 ControlNet Cable and Connectors:
  - .1.2.1 Coaxial Cable:
    - .1.2.1.1 Cable shall be 75-ohm, coaxial cable RG-6 Type, 18 AWG, single conductor, solid.
    - .1.2.1.2 Conductor material shall be bare copper covered steel.
    - .1.2.1.3 Insulation material shall be foam polyethylene.
    - .1.2.1.4 Outer shield shall be Duobond IV quad shield; 100% coverage.
    - .1.2.1.5 Outer jacket shall be polyvinyl chloride.
    - .1.2.1.6 Cable shall be specifically designed for use with Allen-Bradley systems; lengths as required.
  - .1.2.2 Coaxial Tap Kits:
    - .1.2.2.1 Right angle T-tap, straight T-tap, right angle Y-tap, and straight Y-tap as required
    - .1.2.2.2 Allen Bradley 1786-TPR, 1786-TPS, 1786-TPYR, and 1786-TPYS
  - .1.2.3 Coaxial Connectors:
    - .1.2.3.1 BNC Plugs: Allen Bradley 1786-BNC.
    - .1.2.3.2 Terminating Resistors:
      - .1.2.3.2.1 A 75-ohm terminating resistor shall be provided at the each end of a network segment.
      - .1.2.3.2.2 Allen Bradley 1786-XT
      - .1.2.3.2.3 Terminations of ControlNet cable shall be done utilizing the Allen Bradley 1786-CTK termination kit.
- .1.3 Control Cables:
  - .1.3.1 No. 14 AWG minimum, type XHHW-2, low smoke zero halogen (LSZH). Nylon conductor jackets and the use of PVC for conductor insulation or jacketing are not acceptable. Multiconductor and jacketed control cable shall conform to ICEA Method 1 Table E2 for individual conductor color coding.

- .1.4 Modbus RTU
  - 1.4.1 Approved Cable: Belden 82841
- .1.5 Cable installations shall not exceed the manufacturer's recommended minimum bend radius or max pulling tension.
- .2 Process Control Conduit, Raceway, and Supports
  - .2.1 Conduits shall be designed to be rigid with a 1" minimum size. Conduits with more than one conductor shall not be filled more than 40%. A pull wire shall be installed in each conduit and a pull station installed every 30 feet. A junction box shall be installed within 3' of each instrument. The instrument shall be connected to the junction box via Seal Tight. In wet areas, such as cooling towers, there shall be a seal off in the seal tight at the transmitter to protect it from water intrusion. See Division 48 03 04 for detailed installation procedures and requirements.
- .3 Process Control Junction Boxes
  - .3.1 All interior and exterior junction boxes are to be NEMA 3R or better. Junction boxes used on boilers will be NEMA 4X. Conduit entry into junction boxes shall be designed and specified to be from the bottom or the side.

End of Division 40



**Table of Contents**

48 00 00	ELECTRICAL POWER GENERATION (AND ALLIED FACILITIES) .....	2
48 01 01.	Operations & Maintenance .....	2
48 02 00	CONFIGURATION MANAGEMENT .....	3
48 02 01.	Drawing System .....	3
48 02 02.	Software, Firmware Control System.....	6
48 02 03.	Change Control .....	7
48 02 04.	Work control .....	7
48 03 00	DESIGN REQUIREMENTS .....	9
48 03 01.	Power Plant Busses .....	9
48 03 02.	Electrical Component Shielding .....	11
48 01 03.	Wire and Cable.....	11
48 03 04.	Conduit and Fittings.....	14
48 03 05.	Trays.....	14
48 03 06.	Grounding.....	15
48 04 00	MISCELLANEOUS SYSTEMS .....	18
48 04 01.	DC System.....	18
48 04 02.	Annunciators.....	19
48 04 03.	Lighting .....	19
48 05 00	WORK PRACTICES .....	19
48 05 01.	Drawing System, Software and Firmware Control, Change Control, Labeling .....	20
48 05 02.	General Material and Contractor Requirements.....	21
48 06 00	SCHEDULES .....	21
48 06 01.	Schedules (McCracken PP and Smith Sub).....	21
48 06 02.	Schedules (South Campus Central Chiller Plant) .....	22
48 06 03.	Schedules (East Regional Chilled Water Plant).....	23
48 08 00	TRAINING/TESTING AND COMMISSIONING .....	24
48 08 01.	Training.....	24
48 08 02.	Testing.....	25
48 09 00	INSTRUMENTATION & CONTROL FOR MAJOR ELECTRICAL PLANT EQUIPMENT	28
48 09 10.	Design Requirements for Instrumentation and Control for Power Plant and Auxiliary Equipment.....	28
48 09 20.	General Requirements for Control and Instrumentation Circuits and Enclosures .....	32
48 11 00	GENERATION (BULK, PEAKING, AND STANDBY).....	34
48 19 00	POWER PLANT ELECTRICAL EQUIPMENT .....	34
48 19 01.	Fusing and protective Devices (future).....	34
48 19 02.	Generic Specifications (future) .....	34
48 19 03.	Models and Studies .....	35

**48 00 00 ELECTRICAL POWER GENERATION (AND ALLIED FACILITIES)**

48 01 01. Operations & Maintenance

.1 INTRODUCTION: To a large extent the success of any great institution depends on the strength and durability of its infrastructure. A key element of the University infrastructure is its utilities. Electricity plays a vital role in almost every aspect of the University experience from housing through academics and sports to research and allied institutions such as the medical center. Our mission in Utility High Voltage Services (UTHVS) is to provide quality of service and continuity of service with a principal focus on public and employee safety.

The Electric utility infrastructure performance relies on **Maintenance, Equipment Performance** and **Human Performance**.

**Human Performance** relies on training, standards (design consistency), and reliable equipment (good maintenance, sound design).

**Equipment performance** relies on sound design, quality components, and sound maintenance practices.

**Good Maintenance** relies on sound planning, quality components, sound design, and reliable human performance.

No element stands alone. No one element can be sustained without the others. No one element can compensate for the absence of another. This Division of the Building Design Standards sets forth unique requirements applied to address the equipment performance, human performance and maintenance needs of the utility high voltage infrastructure of the University. These requirements should be used in conjunction with the remainder of the University BDS to arrive at a design and implementation that meets the full utility performance expectation of the University and its allied institutions.

.2 SCOPE OF APPLICABILITY: This document provides the requirements and preferred practices of the University as they apply to the McCracken Power Plant and allied facilities such as chemical storage areas, water treatment, standby generation, fuel supply systems and facilities, central chiller and central steam generation facilities and temporary facilities such as portable generation, package boilers etc.

OSU maintains and operates its own utility plants and standby generators. The plants supply steam, chilled water, domestic hot water and compressed air to the University. The scope of application of this document is limited to the above mentioned facilities, and allied facilities. It covers the design and operation of these facilities, for power system equipment and associated controls and protection. Guidance for the design and operation of the electrical systems for the building office space, unless otherwise noted in this document, is contained in Division 26 of the Building Design Standards.

The practices and conventions referenced herein and applied throughout the design of the Medium Voltage Distribution System and its allied facilities are the product of an engineering process directed toward optimizing safe and reliable operations. Compliance with OSHA and National Electric Safety Code requirements is fundamental. Compliance with the National Electric Code is not a design requirement and shall be invoked only on a case by case basis, conformant to the Code applicability statements and where technically useful in obtaining Utilities objectives for overall facility safety and reliability.

A/E and Contractor provisions of this document are intended to promote work practices that:

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

- Adhere in all their procurement and work practices to the OSU Utilities Project Construction Quality Plan
- Conform their construction practices to the OSU Utilities Project Safety and Health Guide

This Division of the Building Design Standard makes reference to various codes and standards. In all cases where there is an apparent conflict between this document and these other referenced documents the requirements of this document shall govern.

### **48 02 00 CONFIGURATION MANAGEMENT**

#### 48 02 01. Drawing System

.1 INTRODUCTION: Utilities maintains a design drawing system as part of the overall Configuration Management program. The drawing system is used to facilitate maintenance, troubleshooting, and to serve as a resource for planning and engineering upgrades and changes to the power plant, substations, and high voltage distribution system. Keeping the drawings in this system accurate, current, and complete can greatly reduce system downtime and improve power system reliability and availability. It also directly affects personnel training, personnel performance and productivity.

.2 DRAWING PLATFORM: The electrical drawing system is made up of a set of specialized drawing types. The types are designed to document and there by facilitate the control of the configuration of various portions of the electrical power system and related equipment; their protection and their control, and monitoring features. Certain projects may require specialized drawings. In general, the drawings maintained by UTHVS fall into four broad categories: One-lines, Schematics, interconnection, and physical layout. The drawings are maintained in AutoCAD.

Utility High Voltage Services maintains or contributes to the maintenance of: Electrical One Line Diagrams for the bulk power and 13.2 KV Primary power distribution, 480 and 208 VAC, 125 VDC; Quad drawings, circuit schematics (data tables); Manhole diagrams and Circuit Risers for the 13.2 KV feeder pairs, and underground. Elementary Schematic drawings for metering and power equipment control and protection; Interconnection diagrams and logics for integrated control systems and interlocking.

The electrical one line diagrams show power sources, major power equipment, their ratings and connections. They also show metering and protection, instrument transformers, major loads, reactors, capacitors, surge arrestors, fuses, circuit breakers, switches, grounding, phasing, and voltage levels present.

Quad drawings are drawings that show the physical layout of the campus overlaid by a specific Primary Circuit Feeder pair. It is a scaled drawing form that shows each manhole and connecting duct bank routing.

Circuit schematics (data tables) show individual Primary Circuits Pairs as a series of duct bank sections and manholes from the substation power source to the extreme ends of the circuits including all branches. These documents also show cable sizes, cable lengths, duct bank occupancy and cable installation dates.

Manhole diagrams show the manhole conduit contents and status for all four walls in a physical portrayal but not to scale. They also show circuit numbers and building lateral destinations.

Circuit riser diagrams DWG 999 E1015 (GE One-lines) are a form of One line diagram used specifically to show Primary Circuit Taps, their associated manholes and the Primary Select

switches and Primary transformers. They show Primary disconnects and the various switching arrangements belonging to the buildings powered from the Primary Circuit pairs. They also contain fuse data for the Primary transformer feeds.

Elementary Schematic drawings show in schematic rather than physical sense, the arrangement and logic involved in both the power connections and switching as well as the logic and components used in design of the control and protection circuitry. They contain the nomenclature used to identify all electrical components as well as the control instruments and interface components such as transmitters, motor operated valves, solenoid valves, positioners, hydraulics, pneumatics etc... They also contain references to vendor supplied drawings, documents and interconnection diagram wire references. Switch and relay contact developments are included on the elementaries to facilitate understanding the control logic.

Interconnection diagrams show how equipment and systems are interconnected (wired and cabled). They may or may not show the relative physical orientation of components. Interconnection, wiring diagrams and or wiring tables give specific information on how equipment is wired on a wire by wire basis and identify physical location and associated reference drawing.

Logic diagrams show the logic used for the control interlocking and protection of equipment and systems. They are primarily schematic and show little or no physical detail other than physical location and elevation.

One lines, elementary/schematics and interconnection/logic diagrams are meant to work as a system, meaning they are cross referenced and contain complimentary information. Duplication of information between drawing types is held to a minimum level needed to facilitate moving between the various drawing types. Each type is designed to assist in accomplishing specific engineering and electrician tasks.

Drawing nomenclature, conventions, and symbology may vary from drawing to drawing. To the extent practical, electrical drawings use nomenclature, conventions, and symbology reflecting general practice in the utility industry.

- .3 **DRAWING SYSTEM NUMBERING:** This drawing numbering system pertains to design, construction and operating drawings documenting designs and as-installed conditions in the Substations and Centralized steam plants and chilled water plants and allied facilities on the Main OSU Campus. The system may be applied after record drawings are submitted at the completion of a project or its utilization may be required of the Design Associate at the beginning of a project, in which case the drawing numbering will carry through from CD throughout the life of the facility. See drawing naming requirements at:

[http://fod.osu.edu/proj\\_del/ref/Electronic\\_Drawing\\_Naming\\_Req.doc](http://fod.osu.edu/proj_del/ref/Electronic_Drawing_Naming_Req.doc)

.3.1 Administration:

A master list (data base) shall be maintained current by the Utilities Division and contain the drawing number, the drawing title, the associated project, the revision number, and the organizational unit responsible for the maintenance of the drawing.

.3.2 Effective Date:

The drawing system was placed in force for all projects issuing CD drawings on and after January 1, 2007 and was applied earlier at the discretion of the Director of Utilities as seen fit to facilitate projects already underway at that time.

.4 **DRAWING MANAGEMENT**

.4.1 CAD file management

The drawing system is managed as CAD files. The files are uniquely named and organized numerically by type of drawing and status (revision and approval). Superseded files are archived along with the current files and are write-protected. Working revisions in development or awaiting approval are password protected. Open revisions are controlled individually. All previous revisions are archived and kept available for reference. All current and active and revision files are maintained on network drives and subject to routine periodic back-up and archival storage.

.4.2 Hard copy access

Current and revision review files are available in electronic and hard copy form on request. Superseded revisions are available on reasonable notice.

.4.3 Inclusion of vendor information

Vendor information in the form of drawings, tables or sketches, when in a compatible format, may be incorporated directly onto the electrical drawings. Project or equipment design specific information should be incorporated into the drawing system. General information should be incorporated into training materials or instruction books and not made part of the drawing system.

.4.4 Inclusion of as-built information

Because the majority of projects are engineered and constructed by other organizations for the university, incorporation of these project files into the utility drawing system is particularly important.

Read-only design drawing files are generally acceptable up until the construction release. Construction drawing release and the release of as-built (as-constructed record drawings) drawings shall be in revisable format compatible with the Universities CAD platform. Construction release drawing files are retained within the drawing system and serve as a reference point for planning and estimating parallel projects. Final project record drawings are incorporated into the drawing system as current drawing revision "0". An archive copy of these files shall also be retained in the respective project record files (record drawings). These revisions are separately identified and given unique drawing numbers.

.4.5 Incorporation of project drawings

Drawings prepared by an associate or contractor for a project shall be prepared with the understanding that the University may incorporate the drawing contents in their entirety or in part into the University drawing system. Drawing completeness, accuracy and drafting quality shall support this. All drawings produced during the course of a project shall become the property of the University in their native revisable and reproducible form.

.4.6 Drawing numbering and revision management

Drawings maintained in the Drawing System are uniquely identified. Each drawing is coded with its drawing type, a project sequence identifier, a title and a revision number.

.4.7 Design standards and Sketch management

The Drawing System shall maintain a set of Drafting Standards and Design Sketches. Both the Standards and the Sketches are managed like drawings, with unique titles and revision numbering.

.4.8 Drawing Index and drawing lists

The Drawing System shall incorporate a procedure governing drawing types, numbering methodology, standard nomenclature and symbology. It shall also incorporate a series of listings containing all the active (current and archived) drawings along with the current revision date. See drawing naming requirements at:

[http://fod.osu.edu/proj\\_del/ref/Electronic\\_Drawing\\_Naming\\_Req.doc](http://fod.osu.edu/proj_del/ref/Electronic_Drawing_Naming_Req.doc)

.4.9 Quality Control

Drawing source material shall be reviewed and accepted for incorporation. All design and drafting work shall be subjected to a rigorous self-checking and independent check for accuracy and completeness. The independent checking shall extend to verifying that all integrated drawings have been properly coordinated, completed or revised.

.4.10 Integrated Design check

Prior to sending out a Construction Drawing set to the University for review, the Engineer shall perform an integrated design check. The design check will verify the interfacing of controls with the current mechanical and electrical drawings and equipment specifications provided.

.4.11 Approval and signature authority

Approval authority for drawings and stamped plans generated external to the University in the execution of projects by the project engineer shall be in conformance with the University process governing the issuance of project drawings.

Approval authority for internally generated drawing additions or revisions of drawings for facilities within the scope of this Standard resides with the Technical Director of Utilities. Signature authority shall be delegated via written form to any qualified member of the Utility staff. The design document shall be initialed by the drafter of record, the reviewer and approved by the Technical Director of Utilities or their designee.

48 02 02. Software, Firmware Control System

- .1 INTRODUCTION: Utilities maintains a system for the control of software based information as part of the overall Configuration Management program. This Software and Firmware control system is used to facilitate maintenance, troubleshooting and to serve as a resource for planning and engineering upgrades and changes to the power plant, substations and high voltage distribution system. Included in this class of information are: Program listings, system and component set-up data, protective relay settings files, fault and coordination files, calculation files and failure data recordings. Keeping the information in this system accurate, current and complete can greatly reduce system downtime and improve power system reliability and availability. It also directly affects personnel training, personnel performance and productivity.

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

- .2 PLATFORM: The University Utility Group can support a variety of platforms. It reserves the right to request compatibility to specific platforms when circumstances warrant.
  - .3 CONFIGURATION SOFTWARE: If the Utilities Division does not possess the software to configure a new PLC or controller, 3 fully licensed copies of the software must be provided with the project. Software must be Windows 7 compatible.
  - .4 ORGANIZATION (future work item)
    - Software/firmware types
    - File content
    - Standards
  - .5 MANAGEMENT (future work item)
    - File management
    - Hard copy access
    - Inclusion of vendor information
    - Inclusion of as-built information
    - Incorporation of project software, configurations and settings
    - File identification and revision management
    - Design standards and Sketch management
    - Index and listings
  - .6 QUALITY CONTROL (future work item)
  - .7 APPROVAL AUTHORITY (future work item)
- 48 02 03. Change Control
- .1 CHANGE AUTHORIZATION: Work that exceeds basic maintenance and repairs or that changes the design, system operation or materials of construction in the power plant, substation, or primary distribution systems requires prior authorization of the Technical Director of Utilities or designee and qualified design oversight and inspection. This requirement applies to systems that are in operation as well as systems that are being installed to approved construction documents. Approval authority may be delegated by the Technical Director of Utilities to the construction authority for projects under construction. Approval authority may be delegated to subordinates in Utilities.
  - .2 WORK SCOPING AND DOCUMENT IMPACT IDENTIFICATION: The nature of the proposed changes shall be clearly defined. A technical and cost justification shall be provided. The anticipated impact on existing facility systems and equipment shall be assessed, including constructability, startup and maintenance considerations and "What if" risk assessment on equipment, systems and human failures that could result in utility outages. (See 48 09 10.9 for additional information) Compliance with OSU BDS and its appendices shall be established. Personnel training and familiarization needs as well as maintenance needs shall be outlined. The impact on drawings, procedures and practices shall be described. A Failure Modes and Effects Assessment shall be provided for use in determining the potential impact on the design of facilities, structures, support systems and utilities as well as the acceptability of the consequences of a failure.
- 48 02 04. Work control
- .1 DEVICE AND CABLE NUMBER ASSIGNMENT: Unique device and cable numbers shall be assigned according to Utilities naming and numbering conventions.

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

- .2 **DRAWINGS:** All work shall be installed to original issued signed and stamped drawings, approved marked-up drawings or detailed sketches. New drawings and sketches shall conform to Utility practices for content and information organization. Installation using pre-approved marked-up University drawings is acceptable if the mark-ups show adequate detail to be used to control the installers' materials and practices and present a usable and complete record of the final installation.
- .3 **QC CHECK POINTS:** The installation shall proceed with preplanned hold points to allow for work inspection by the Utility or an independent third party inspection and test agency. All critical tasks shall be done by qualified trained personnel.
- .4 **ELECTRICAL INSPECTION:** Electrical inspection for completeness and compliance to the BDS, Code, Good Practices and the Design shall be performed on a regular basis for the various portions of the installation as the project progresses. This may be performed by the prime contractor, Utility personnel, or an independent agency. However the responsibility for seeing that this function is performed to the satisfaction of UTHVS rests with the prime contractor. Discrepancies and omissions shall be followed up and corrected in a thorough and timely fashion. Reference construction inspection checklists for primary electric service, when applicable.
- .5 **CHECKOUT AND COMMISSIONING:** There shall be a formal independent check-out and commissioning process. This activity shall be pre-planned and thoroughly documented. All test and calibration equipment shall be National Institute of Standards and Technology (NIST) (or Utility approved and appropriate agency) traceable.
- Checkout shall verify all protection, interlocking, control functions, and alarming are operational and to spec.
- Commissioning shall demonstrate that all systems are operational (meet fitness for use requirements); personnel are trained in operation and maintenance.
- Third party involvement for the checkout and commissioning of Medium voltage equipment and systems shall be by a qualified Relay Checkout Organization (RCO) with a documented history of successfully conducting such work and staffed at a technical level adequate to perform an engineering review of the design as or if required.
- Third party involvement for the checkout and commissioning of Low voltage equipment and systems shall be by a qualified Independent testing service (ITS) with a documented history of successfully conducting such work.
- .6 **JOB STATUS TRACKING:** Status and tracking shall be appropriate to the size and complexity of the project. At a minimum all changes shall have their approval, implementation and documentation status recorded and tracked; open items and follow up activities noted.
- .7 **DOCUMENT UPDATES, RECORD DRAWING RELEASE AND AS-BUILTS:** All University documents impacted by the change shall be updated. Project drawings shall be updated and kept current with as installed conditions and at completion of project, incorporated into the appropriate University drawing system. Vendor supplied documents with maintenance, trouble shooting and operation of equipment information shall be assembled and included in the Project O&M Manuals and retained in the University Vendor Document Control System.
- .8 **PROJECT CLOSE-OUT PACKAGE:** Each change shall have a close-out package on file that contains the scoping and authorization documents, as-built record drawings, supporting vendor and technical correspondence, catalog information and, Project O&Ms. The package shall also contain a record of the change being functionally tested and released for operation.



A record of training along with training materials shall be included. Reference Project Closeout:

[http://www.fod.ohio-state.edu/proj\\_del/index.htm](http://www.fod.ohio-state.edu/proj_del/index.htm)

**48 03 00 DESIGN REQUIREMENTS**

Requirements of this Standard are based on good engineering practice and provide a uniform and consistent basis for the design, construction, maintenance and operation of electrical infrastructure and the electrical portions of Utility facilities on the OSU Main campus. Utilities UTHVS maintains a Planning and Design Guide that provides the technical basis for many of these requirements and should be consulted before recommending alternatives or any nonconformance.

**48 03 01. Power Plant Busses**

.1 **INTRODUCTION:** The primary objective of dividing plant boiler and chiller loads between the two primary feeds is to achieve some level of tolerance in the power plant to electrical system upsets. Major upsets originating with the external utility, AEP, will impact all boilers and chillers. The electrical system is equipped with emergency generation capacity to restart power plant boilers individually and re-establish critical steam loads, with the further objective of re-starting internal steam powered generation and re-establishing some critical electrical distribution circuits. For internal upsets, we seek to limit the potential impact to no more than half our steaming or cooling capacity. Grouping auxiliaries for each boiler or chiller facilitates switching during a power outage and limits the impact that an internal power outage will have on boiler and chiller operation.

.2 **GENERAL CONSIDERATIONS:** McCracken Power Plant electrical supplies are organized to limit the number of boilers and chillers impacted by the loss of any one bus or feeder. McCracken Power Plant receives power from three incoming feeds at 13.2 KV. These feeds are powered from OSU Sub and enter Smith Sub where they power Forced Draft (FD) fan Variable Frequency Drive's (VFD) for Boilers 1, 3, 5, 6 and 7. Two feeders, 412 and 612, fed from Smith Sub, power the power plant 480 VAC system. Plant chiller loads are powered at 4160 VAC from Smith Sub 4160 V systems and from the plant 480 V systems. The bus arrangements at Smith Sub support two independent feeds to the plant; one orientated to bus 400, one to bus 600. These busses are in turn fed from bus 100 and bus 300 respectively at OSU Sub. Each of these two busses can be alternatively fed from bus 200 at OSU Sub through bus 500 at Smith Sub.

Bus 400 orientated busses and feeders are: 13.2 KV Bus 401, 13.2 KV Feeder 412, 13.2 / 4 KV Transformer T1400 (North), 4160 V Bus 1400, Chiller Bus 89, FD Fan bus 1401, Transformers T2 and T3, 480 V Sub 2 and 3, T5, 480 Sub 5, Smith Sub 480 V MCC 2.

Bus 600 orientated busses and feeders are: 13.2 KV Bus 601, 13.2 KV Feeder 612, 13.2 / 4 KV Transformer T1600 (North), 4160 V Bus 1600, Chiller Bus 67, FD Fan bus 1601, Transformers T1 and T4, 480 V Sub 1 and 4, Smith Sub 480 V MCC 4.

All boilers and chiller groups have an orientation to either Bus 400 or Bus 600. This orientation governs the choice of chiller power as well as the choice of power sources to their respective auxiliary equipment (fuel oil pumps, ID fans, boiler feed pumps, chilled and condenser water and associated control power). Where redundant auxiliaries have been provided, the power orientation of all redundant auxiliaries shall be the same.

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

- .3 MEDIUM VOLTAGE DISTRIBUTION SYSTEM: The McCracken Power Plant 5 KV power distribution system is supplied from two 10 MVA 13.2 KV to 4160 Volt power transformers located at the McCracken Substation. Each of these transformers powers a 4160 V bus that in turn powers miscellaneous plant boiler fans and large pumps as well as the larger chiller package compressors. Both of these busses are equipped with 2300 KVA emergency diesel generators capable of supplying critical plant electrical loads.
- .4 LOW VOLTAGE DISTRIBUTION SYSTEM: The McCracken Power Plant 480 V power distribution system is supplied from one single ended and two double-ended unit substations located within the power plant. One double-ended substation (unit subs 1 and 2) is located in the MCC room. The other double-ended substation (unit subs 3 and 4) is located on the mezzanine on the east wall of the power plant. The single ended substation (unit sub 5) is located in north eastern end of the basement. The McCracken LV distribution is a mix of solidly grounded and resistance grounded distributions. Sub 1, 2 and 5 are operated high resistance grounded with ground location. Sub 3 and 4 are solidly grounded 3 wire systems. There are plans to convert these to resistance grounding. Plant loads are 3 phase or connected phase to phase. Single phase to ground loads are not permitted. Running a loadable neutral wire along with phase leads is not a requirement of the distribution system design.
- .5 NEW CENTRALIZED FACILITIES: New facilities and major additions to facilities that have built-in redundancies of equipment or functionality shall be designed with electrical distribution systems that support and mirror those redundancies. The most common power system redundancies are designed around two or three bus schemes and reflect how the energy supply to the facility is provided. Facilities fed directly from the main OSU or West Campus Substation buses can be designed around a maximum of three buses as is the case with the South Regional Chiller Water Plant. Facilities fed off the MV distribution system sharing primary distribution system circuits with other buildings and facilities will generally be designed around a two bus scheme to keep feeder loadings within system design criteria contingency loading limits as is the case with the East Regional Chilled Water Plant. Both the South central Chilled Water and East Regional Chilled Water facilities have their Low Voltage distributions rated 575 V resistance grounded. Both also have their chillers powered off 5 kV busses. The 5 kV systems at both locations are low resistance grounded as well to reduce fault induced equipment damage and Arc flash levels.
- .6 STANDBY POWER GENERATION: Standby power sources provided for, or as an adjunct to OSU Utility Facilities, designed with the capability to be operated in parallel with the MV distribution system shall be provided with a means to automatically isolate from the system upon loss of external utility connection.

Normally a standby power system will be automatically started on loss of external utility power and support a limited portion of the MV distribution, typically MV distribution within a facility such as a central chiller plant or the McCracken power plant. In this mode, they are not operated in parallel to the outside utility except to transfer load back to the external utility once the normal source of external power is restored. It is quite common however to run periodic load tests with the standby power system connected to the external utility. This is done to avoid the cost of a load bank installation and to conserve energy. It is under such conditions that this requirement applies.

Separation may be accomplished by direct interlocking or it may be accomplished through a reliance on protectives applied to the standby generators. OSU Utilities has a standing commitment with the external utility (American Electric Power) to advise them of the presence of standby generation on the OSU MV distribution system and keep them apprised of any changes in capacity, interlocking or protection provided. Principal among concerns for what is generically termed "Distributed Generation" is the potential for it to back feed into the external utility grid and cause a concern for personnel safety and equipment damage.

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

There are two MV Standby Power systems allied to Utilities facilities on the Main Campus; one at Smith Substation for McCracken Plant and one situated northwest of McCracken that supports the South Regional Chilled Water Plant. As part of the McCracken power plant LV system there is a single independent DG set aligned to Sub 2 480 V distribution. Standby Power System loading at Smith and the Chiller support facility involves load shedding and manual load restoration.

### 48 03 02. Electrical Component Shielding

Solid state and microprocessor based components applied in mission critical functions in the Bulk Power System shall comply with accepted industry standards for emission and susceptibility to Radio Frequency Interference (RFI), magnetic fields, Electro-static Discharge (ESD), ultra violet radiation, temperature, humidity, chemical attack and vibration. Careful attention shall be paid to these aspects of the application of this class of equipment because this relatively sensitive equipment will be placed in service in or in close proximity to sources of adverse environments and high-energy fields. Proof of equipment compatibility and documentation of its compliance to industry standards will be required before final acceptance.

### 48 01 03. Wire and Cable

.1 COPPER CONDUCTORS: Copper conductors of 98 percent conductivity shall be used unless use is restricted by Government Agencies.

#### .2 COLOR CODING

Color coding for power wiring in McCracken Power Plant and allied facilities shall be as follows:

<u>Phase</u>	<u>Voltage</u>		
	4.16KV	575, 480Y/277	240/208/120
Neutral	White or Grey (Each with identifiable colored stripe)	White or Gray	White
A	Brown	Brown	Black
B	Orange	Orange	Red
C	Yellow	Yellow	Blue
Equipment Ground	Green, Black or Bare	Green w/ Yellow stripe	Green

Control wiring at 125 DC, 120 AC are not generally color-coded in panels, nor is there a prescribed conductor color associated with the voltage or polarity when run in jacketed multi conductor color coded cable.

#### .3 MEDIUM VOLTAGE CABLE (5 KV)

5,000-volt service cables shall be UL Listed, 1/c, copper, 115 mil Ethylene propylene rubber insulated, 5 kV, 133% rated, shielded, MV 105° cables with low smoke (critical Temperature Index > 260°C) zero Halogen\*. Tape Shield Cables shall have a 5 mil bare copper tape applied helically over the extruded insulation shield with an average minimum overlap of 25 percent of the tape width. The overall jacket shall be a continuous extruded, 80 mil polyolefin jacket which meets or exceeds the requirements of ICEA S-93-639 WC 74.

\*Note: The zero-Halogen requirement may be waived by UTHVS for applications where halogen bearing cable jacket material poses little or no risk to personnel or equipment. OSU Utilities maintains a listing of approved cable suppliers and approved cable jacket constructions.

**.4 GENERAL REQUIREMENTS FOR MEDIUM VOLTAGE CIRCUITS**

- .4.1 Circuits shall be rated to carry a minimum of 120% rated continuous load at a 60°C ambient. If an emergency rating is involved, the installation shall be designed to 120% of the emergency duty rating. The minimum size cable allowed for medium voltage feeder circuits is 4/0. Individual motor and load circuits can have reduced wire sized commensurate with the requirement of the NEC. All medium voltage circuits shall be shielded cable unless otherwise authorized in the design drawings and approved by UTHVS.
- .4.2 Circuits shall be routed in bonded steel conduit with a diameter of 4 inches or greater as required by the choice of cable conductor and configuration. Use of aluminum conduit is not permitted. Tray installation of MV power cable is restricted to areas of the power plant substation where environmental effects are controlled and physical protection can be assured. Power cable runs in tray shall conform to the NEC requirements for multiple conductor transposition, cooling, and shall have a 4/0 600 volt insulated ground conductor run for each set of three phase conductors in the circuit.
- .4.3 Minimum bend radius considerations for the cable shall be observed at all times during installation and in the final installation and terminations.
- .4.4 Oversized motor terminal boxes shall be specified to allow adequate termination space for motor leads to shielded cables
- .4.5 Use of unshielded cable is restricted to locations where termination of shielded cable is not practical such as undersized motor terminal boxes. Use of unshielded cable must be approved in writing by UTHVS prior to installation. Such approval may be granted on a case by case basis for instances where the entire cable route is in rigid or flexible metallic conduit.
- .4.6 Cable medium voltage terminations and splices shall be done with UTHVS approved Raychem Heat Shrink termination and splicing kits. All exposed energized surfaces on terminations shall be taped with UTHVS approved taping systems. Motor and equipment terminations to unshielded MV cable shall be taped or insulated with OSU Utility UTHVS approved taping systems or termination kits. All terminations shall be via bolted. Split bolts and pressure type fittings are not permitted. Cold shrink terminations are not approved. Certifications of the proposed installers shall be submitted to the University for review by the UTHVS personnel. All work performed on non-lead, medium voltage (1 kV to 35 kV) cables shall be performed by personnel with adequate training and experience, and certified as qualified by the UTHVS. To be considered qualified for cable splicing, the individual's employer must submit a resume with past training and experience supported by documentation of their having had the appropriate formal training in the preparation of relevant medium voltage splices and terminations, prior to the individual performing any work. Splicing and termination experience shall be recent (one to five years depending on extent of prior experience) and relevant to the type of splice and cables being spliced.
- .4.7 Fire tape is applied to exposed cable for the purpose of protecting that cable from the failure of adjacent cables. For the purposes of this discussion, "exposed cable" refers to cable hung in air or run in ventilated tray. Cable in conduit requires taping only to

the point where the cable enters and exits the conduit. Cable vaults and Manholes are areas commonly associated with the need to fire tape however the criteria governing taping is broader and may require taping in other areas of an industrial facility such as a power plant or central chiller facility. The application of fire tape serves two purposes. It limits the proximal damage caused by a cable failure and it reduces the probability that a cable failure will result in the loss of redundant circuits. This is true for instances where there is little risk of a general area fire caused by a large combustible inventory. Where an area fire is a serious concern, the recommended solution is to reroute critical cables and/or their redundant cables. The application of fire tape to cables in or out of trays offers some protection from an area fire of limited duration and intensity. Where there is little or no risk of an area or tray fire, adding barriers to trays containing redundant cables or placing redundant cables in separate trays is an acceptable design approach.

.5 LOW VOLTAGE CABLE (600 volt class): For Power, Control and Protection

NOTE: Some Utilities central facilities 480 VAC and 575 VAC sources are solidly grounded but most are operated ungrounded. The choice of power source will materially affect the circuit protection design and may also effect the application of solid-state power switching equipment such as variable frequency drives. All protection and equipment designs shall accommodate the grounding condition for the power supply provided.

- .5.1 Solid and stranded insulated conductor Wire: No.12 AWG and smaller may be solid. No. 10 and larger shall be stranded.
- .5.2 Minimum size for all 125 VDC and 124/240 VAC branch circuits is No. 12 AWG.
- .5.3 Minimum No. 14 AWG stranded for AC control wiring and auxiliary system circuits is permitted.
- .5.4 Use of No. 12 AWG or greater for 125 VDC control wiring is required.
- .5.5 Use of No 10 AWG for all current transformer circuit wiring is required.
- .5.6 General Use insulation for 600 volt rated wire and cable shall be NEC, 600 volt class type XHHW2 with SIS allowed for power component internal control wiring. Jacketing shall be Low Smoke Zero Halogen. Nylon conductor jackets and the use of PVC for conductor insulation or jacketing are not acceptable for power plant, substations and associated facilities applications. All wiring between equipment, cabinets or control panels for low voltage power equipment power and control circuits shall be in conduit or tray. All control wiring between power components, cabinets and control panels shall be in jacketed color coded tray cables bearing suitable durable cable identifiers. Panel and component wiring shall have individual wire labels. Acceptable labeling conventions include: destination labeling, unique wire numbering. Distribution panel branch circuits at 120 Vac and 125 Vdc, powering controls for electrical and I&C equipment are classified as control cable and run in color coded jacketed multi conductor cable. Wire sizes AWG 8 and larger are exempted from this rule.
- .5.7 ICEA Method 1 Table E2 convention shall be used to color code individual conductors of all jacketed multi-conductor cable. Equipment manufacturer supplied "special cables" are exempted from this requirement.
- .5.8 All power cables are to be terminated in UTHVS approved solid, long barrel, plated lugs. Power cables carrying high current (greater than 50 Amps) are to have two or more bolts. Crimps are to be made by a crimp tool approved by the lug manufacturer following their approved procedures. All crimps shall be six point or more. A 360 deg

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

crimp is preferred. In instances where the equipment taking the termination does not support two or more bolts, UTHVS shall be consulted and will determine the acceptability of the single bolt termination. Mechanical type connectors are not generally considered acceptable for power applications. Bolted connections shall be torque to appropriate levels.

### **48 03 04. Conduit and Fittings**

- .1 Conduit shall be rigid steel except as noted in section 48 03 05 below. EMT and Aluminum conduit are not permitted for control or power circuits except as noted in section 48 03 05 below. Galvanizing or corrosion protection is required when conduit will be placed in a known corrosive environment or where it will be exposed to moisture or the elements. Fiberglass conduit is permitted only in tunnels areas where wet conditions persist. It is not permitted for general use or in explosion hazard areas (Class I Div. II or more stringent).
- .2 Conduit shall be sized for the number and gauge of the wire contained. The minimum conduit size allowed is 1 inch conduit. NEC requirements for conductor count and fill shall be followed for power cable except where specifically waived by UTHVS.
- .3 Pull boxes shall be spaced at appropriate intervals to allow for pulling cable and not exceeding the manufacturers maximum pulling tension or side wall pressures.
- .4 Cable minimum bend radius limits shall be observed for all cables during installation and in the final installed condition. "L" boxes shall not be used for shielded power cables, multi-conductor control or instrument cables with more than four conductors of AWG #14 wire or greater.
- .5 Conduits and boxes shall be routed and installed clear of traffic areas, equipment access lay-down or removal areas, mechanical equipment subject to high temperatures, movement, or thermal displacement.
- .6 Conduit shall be supported at regular intervals in both the vertical and horizontal directions.
- .7 Multiple circuit power cables shall have all three phases and ground present in each conduit.
- .8 All rigid steel conduit shall be provided with grounding bushings.
- .9 Fittings shall be threaded, 2" diameter and below with insulated throats, 2.5" and above with grounding bushings. Compression connectors are permitted where use of threaded fittings are not practical subject to prior written approval by UTHVS. Set screw and die cast type couplings and connectors are not allowed.

### **48 03 05. Trays**

- .1 Trays may be used for power, control or instrument cable in areas known to be free from injurious chemical environments significant dirt or debris accumulation, physical, and explosion hazards. Construction of all trays shall be galvanized steel with limited exceptions for MV power cable trays
- .2 Power trays shall be ventilated, expanded metal construction or ladder style. Multi-circuit power cables shall have their phase circuits transposed to avoid heating from circulating currents in the tray. In corrosive or damp environments or where dirt accumulation will be heavy, galvanized steel conduit shall be used. Aluminum ladder tray may be used to support MV cable.

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

- .3 Control and Instrument trays may be ventilated or enclosed construction, solid metal construction is preferred. The tray shall be enclosed and covered in areas where dirt accumulation is anticipated. In corrosive, dirty or damp environments galvanized steel conduit should be used. Control and Instrument trays shall not contain AC power cables. Power cables are defined as cables supplying power to motor driven equipment, heaters, transformers etc. or power distribution panels where the loading of the cable may be substantial. Branch circuits serving only control loads with low to negligible circuit loading may be exempted from this requirement.

125 VDC and 120/240 VAC control cables should not be placed in with instrument (analog or digital) signal cables if possible. If they do share tray they should be separated by a physical metallic barrier. Control and instrument cable may share tray or conduit for short runs (10 ft or less) when entering equipment or where cable access is limited.

- .4 All trays shall be grounded. A continuous 4/0 stranded bare copper conductor shall be run the length of the tray, clamped or bonded to each tray section, and run to building ground directly or through building steel at intervals along the tray run not to exceed 100 lineal feet of tray. This ground cable shall be run external to the tray and not placed in the tray with the electrical cables.
- .5 All trays shall be sized for the intended tray loading and supported at regular intervals to building structural elements. Supporting tray from equipment, ductwork, pipes or pipe hangers is not permitted.

### 48 03 06. Grounding

- .1 **GENERAL:** Station grounding is provided for personnel protection, reduce equipment over-voltage exposure due to lightning, and to control stray voltage caused by static charges and electrical faults. Equipment case or enclosure grounding serves the same purpose. Grounding of major power components serves the purpose of conducting equipment fault currents safely away with very little increase in local contact potential.

McCracken Power Plant has been provided with a continuous ground bus that runs the perimeter of the basement elevation. This ground bus is tied to the Smith Sub grounding system at multiple points. As a preferred practice, all grounds should be run to this bus. An acceptable alternative, equipment and enclosure grounds can be run and bonded to adequately grounded, pre-existing equipment skids, or building steel so long as the maximum ground resistance limitation is observed (see section 1.02.03).

New Facilities shall be provided with a continuous ground bus that runs the perimeter of the basement elevation in the areas where power cable or equipment is located. This ground bus is tied to the building grounding system at multiple points. As a preferred practice, all grounds should be run to this bus. An acceptable alternative, equipment and enclosure grounds can be run and bonded to adequately grounded, pre-existing equipment skids or building steel so long as the maximum ground resistance limitation is observed (see section .2.2.3 below).

McCracken Power plant has been provided with an isolated instrument system ground bus distributed throughout the basement elevation that serves as a high quality ground bus for control cabinet instrumentation system ground. This distributed ground bus is made up of 4/0 600 volt class insulated cable and is brought to ground at one point on the plant continuous perimeter ground bus. This is an instrument ground system and not intended for use to ground enclosures for safety purposes. Safety grounds and instrument grounds are to be kept isolated except where the two systems are joined at the perimeter ground connection.

New Facilities shall be provided with an isolated instrument system ground bus distributed throughout the building elevations that serves as a high quality ground bus for control cabinet

instrumentation system ground. This distributed ground bus should be made up of 4/0 600 volt class insulated cable and brought to ground at one point on the plant continuous perimeter ground bus. This is an instrument ground system and not intended for use to ground enclosures for safety purposes. Safety grounds and instrument grounds are to be kept isolated except where the two systems are joined at the perimeter ground connection.

.2 PRACTICES

- .2.1 Grounding practices shall reflect IEEE Std. 142 Recommended Practices, and IEEE Std. 665 Guide for Generating Station Grounding.
- .2.2 Grounding systems applied shall conform to applicable requirements of the National Electric Safety Code for medium voltage installations (15 and 5 KV) and the NEC for low voltage installations. Where NEC requirements conflict with this specification, this specification shall govern.
- .2.3 All connections in the grounding system shall be clamped, exothermic welded, Cad Weld or equivalent. Individual grounding rods connected to the grounding system shall have a measured ground resistance of ten ohms (10  $\Omega$ ) or less. This measurement may be made by any of the commonly accepted methods for measuring ground rod resistance to earth. Grounding for power equipment power circuit neutral grounding shall be no greater than one tenth ohm (0.1  $\Omega$ ) measured from the neutral bus to the local ground bus or grounded building structural steel. Primary circuit (13.2 kV system) grounding shall conform to the NESC for potential rise during ground fault. Ground resistance shall be no greater than three ohms (3  $\Omega$ ) for cabinet and control circuit grounds. Only copper to copper ground connections may be clamped or bolted. All other terminations shall be exothermally welded (Cadweld<sup>®</sup>ed).
- .2.4 All medium voltage and low voltage power apparatus enclosures shall be grounded by two independent paths separately attached to a common ground bus or ground reference. Equipment skids and multiple equipment enclosure line-up shall have two independent 4/0 grounding points. For one of these ground points, individual cabinets and small enclosures (e.g. lighting transformers) can utilize the ground carried back to the supply panel with the power cable as long as this conductor carries no load current and is properly identified as a grounding conductor. Multiple groupings of enclosures can have their equipment grounds daisy chained and do not require that both ground paths be direct to building or station ground so long as the maximum ground resistance limitation is observed. Portions of equipment skid may require separate grounding accommodations where vibration eliminators, nonconductive expansion joints or galvanic protection (isolation points) have been installed. These applications must be referred to the Design authority, UTHVS or the equipment manufacturer to establish the proper grounding design.
- .2.5 Design Drawings shall show ground systems, protective conduit sizes, and relative locations. Specifications and drawings shall include detailed requirements of the grounding system. Each design should have a detailed grounding plan that adequately describes the grounding requirements for the enclosure/skid and also the grounding requirements for major powered electrical components contained therein.
- .2.6 Grounding systems shall at a minimum conform to applicable requirements of the National Electric Safety Code (NESC) for medium voltage installations (13.2 and 5 kV) and the NEC for low voltage installations. Where NEC requirements conflict with this Standard, this Standard shall govern.



## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

- .2.7 Where an existing ground bus system is provided, equipment grounds shall be brought to this system at the nearest point and attached via bolted connection or bonding (McCracken Power Plant basement elevation). Where a ground bus has not been installed, equipment grounds shall be brought to the nearest ground point which may be a ground cable, ground node or grounded building steel.
- .2.8 A ground bus shall be provided in any room or area where electrical power equipment (switchgear, motors, transformers etc.) are congregated. The grounding bus shall be continuous and traverse the perimeter of the room or area. It shall be bonded to structural steel and any existing ground busses or grounding systems in the vicinity. The bus shall be fabricated out of minimum 4 X ¼ inch electrical grade copper bar stock. Ground bus joints shall be bolted in a 4 bolt pattern or brazed. If the area extends beyond the foundation line of the plant, ground rods shall be driven at 20 foot intervals (or at alternate grid intersection points along the perimeter and bonded to the ground bus using bare 4/0 solid or 4/0 7 stranded copper cable. Self-standing structures with a 10,000 square foot footprint or greater containing electrical power equipment shall be provided with a ground mat made up of bare 4/0 solid copper cable maximum 10 foot spaced in a grid pattern with all joints bonded together and with 4/0 bare copper risers bonded to structure steel and brought above grade to the building ground bus at two or more independent locations, preferably at extreme opposite ends of the ground mat. Smaller structures and all structures with conductive walls or architectural features shall be provided with perimeter grounds bonded to the building ground system and attached via bare 4/0 copper ground cables to ground rods spaced a maximum of 20 foot apart along the perimeter.
- .2.9 Grounding cable shall be bare 4/0 copper. Solid conductor 4/0 cable shall be used for buried installations, in locations subject to chemical attack or persistently damp conditions, and to ground permanent structures. Stranded 4/0 7 conductor) may be used with the written approval of UTHVS as an alternative. 4/0 19 strand cable is acceptable above grade for supported ground cable runs in or on trays or structures and where the ground cable is likely to need to be removed for equipment maintenance or replacement and corrosion is not expected to be a concern.
- .2.10 Conductor and insulation when specified shall conform to the following requirements:
- .10.1 4/0 bare solid conductor shall be used in applications where the conductor is placed below grade or in a corrosive environment.
- .10.2 4/0 bare medium stranded (7 conductor) may be used in lieu of solid conductor in below grade applications and in mildly corrosive environments, and where conductor flexibility is a consideration.
- .10.3 4/0 bare high stranding (up to 19 strands) is permitted in all above grade applications where exposure to corrosives is not a concern.
- .10.4 All 4/0 bare copper ground cables shall be properly supported:
- |                   |                                     |
|-------------------|-------------------------------------|
| Solid:            | supported at 4 foot maximum spacing |
| Medium stranding: | supported at 3 foot maximum spacing |
| High stranding:   | supported at 2 foot maximum spacing |
- .10.5 Ground cables may be required to be insulated based on their use.
- Transformer and generator neutrals connected to neutral resistors or reactors to limit ground fault currents must be insulated. Cable insulation shall be line-to-line voltage rated. Ground cables running from the Grounding

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

resistor/reactor and station ground shall be bare 4/0 copper unless specified differently in the design.

- .10.6 4/0 ground cables run in conduit or tray with feeder cables shall be insulated to avoid the possibility of arcing from stray ground currents during a power system ground fault. The insulation system required in this application is 600 volt class.
- .10.7 All control panel and instrument cabinet instrument signal grounds (high quality grounding requirements) will be grounded to the nearest instrument grounding bus. In remote areas where instrument grounds do not exist, they must be installed by the contractor under the guidance of the Utilities High Voltage Shop.
- .10.8 All remote electrical equipment, temporary service switches and outlets are to be grounded. Power panel branch circuits powering duplex outlets shall not be supplied through GFI or ACFI at the source but, if a GFI outlet is required, have the GFI local to or integral with the local service connection or outlet.

### **48 04 00 MISCELLANEOUS SYSTEMS**

#### **48 04 01. DC System**

- .1 The Plant DC system is rated 125 VDC and is operated ungrounded.
- .2 The DC system must be supplied with ground detection and equipped to alarm off nominal voltage, ground, charger failure and loss of AC power to the charger.
- .3 DC system protection shall be provided either by selectively applied Fuses or Circuit breakers. Protection is designed to isolate and eliminate faults. Battery and main distribution circuit fuses and breakers shall be sized to accommodate the short circuit duty of the system. The Battery shall power the DC system through a circuit breaker or fuse rated to ride through all DC system load faults, distribution system cabinet faults, and charger faults, and open only for a sustained fault condition on the battery leads and their connection to the distribution panels and chargers.
- .4 DC system loads shall be restricted to loads required for the safe and reliable operation of the power system. This includes any circuits, loads or devices requiring uninterrupted power availability during facility AC transients or loss. Examples include switchgear control, some motor operated valves, critical instrument and control inverters and emergency lubricating oil systems.
- .5 The normal source of power to DC loads shall be the battery charger, with the battery receiving a float charge. In critical applications the University may require redundant battery chargers aligned in a primary and backup configuration. Switching may be accomplished with a transfer switch (not preferred) or through the use of output isolation devices in each charger. An acceptable alternative to two permanently installed chargers is a crosstie to another battery system or a provision to attach a temporary charger.
- .6 The battery is the principal source of DC power to the DC system. The system control, monitoring, and provisions for maintenance and protection shall reflect this.
- .7 DC System loads shall not require a battery tap, but shall be designed to operate at full battery voltage under normal and equalize voltage conditions. The use of low voltage control

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

devices with series resistors is discouraged with the exception of indicating lamps that require series resistors for circuit reliability reasons.

- .8 Surge or transient suppression schemes that can provide a short circuit path between battery positive and negative or from battery positive and negative to ground shall be fused.
- .9 All circuit alarming and monitoring devices connected to the DC system shall be fused.
- .10 Central DC system batteries shall be of the Substation type rechargeable wet cell design. They shall have a 20 year service life or better and be contained in transparent jars designed to facilitate the inspection of the battery internals. The Jar size (number of individual cells contained) shall be limited to what can be managed for replacement by two persons. The battery cells shall be housed in a suitably ventilated, lockable enclosure. The selection of battery technology shall appropriately reflect the service requirements and the ratings and limitations of the powered equipment.

### **48 04 02. Annunciators**

- .1 Local annunciators and remote annunciators shall be equipped with identical displays. All annunciators and remote annunciators shall be fully supervised, and annunciator systems shall be self-monitoring. The exact annunciator sequence for acknowledgement, test and reset will be determined by Utilities UTHVS for the specific design application.
- .2 Annunciator power shall be supplied from the facility 125 VDC system. The annunciator system shall be designed to operate on a 125 VDC ungrounded system and be able to handle the transients common to such a system caused by the operation of electromechanical devices on that system and ambient radiated and conducted EMI emissions. Contact whetting may be off the 125 VDC system or an annunciator system generated source of voltage; 100 VDC or higher. The system shall be designed to recognize a contact closure or opening as the alarm condition.

Annunciation may signal critical system abnormal conditions such as failures and trips, conditions requiring prompt maintenance and conditions requiring routine maintenance follow-up or no immediate action (system status). The Annunciator system shall be designed to provide remote access to system and alarm point status as well as marshal alarm points into at least three categories of alarm for Utilities' use in dispatching personnel for follow-up.

Audible alarms shall be provided only if expressly required by UTHVS. Generally, audible alarming for facilities having a central or remote control station location is not desired because of the nuisance. The same is true for visual indication (strobe lights).

### **48 04 03. Lighting**

- .1 The lighting design shall provide for both task and access/egress lighting.
- .2 Task lighting shall be at illumination levels appropriate for reading labels, metering, test instruments, and written instructions.
- .3 Access/Egress lighting levels shall be adequate to insure that personnel gaining access to and traversing or leaving plant areas can move safely and efficiently without concern for obstacles, tripping and bumping hazards.

### **48 05 00 WORK PRACTICES**

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

All work performed in and for the McCracken Power Plant, central chiller and central steam generation facilities, and Allied Facilities shall be strictly controlled. These are operating facilities. As such, removal of equipment from service, starting, and operating equipment, connecting temporary loads, selection and assignment of power feeds, storage of construction materials, supplies, chemicals, and tools are under the control and at the discretion of Utility Management, Plant Operations, and Plant Maintenance staff.

All work shall be performed in accordance with approved drawings.

All work shall conform to the plant safety rules, processes and procedures. No work shall be commenced without the approval of the Power Plant management. Pre-job briefing of work crews is mandatory at the beginning of every shift. It is required that the contractor remains informed of the operating condition of the facility and provide continuous supervision of construction workers. Work space cleanliness shall be observed at all times. Leaks and spills shall be contained and cleaned up promptly. Waste materials shall be placed in suitable containers and removed at the end of every shift or work period.

All work space shall be returned to a clean and safe configuration at the end of the work shift or work period

### 48 05 01. Drawing System, Software and Firmware Control, Change Control, Labeling

- .1 An engineered schematic design and vendor shop drawings must be submitted and approved by UTHVS before manufacturing and shipment is authorized. In addition, the University may also elect approval by inspection at manufacturer's plant before manufacturing and before shipment are authorized.
- .2 Drawings submitted as "Construction" drawings shall be provided in reproducible but not alterable form for "record" as well as in native revisable format. The revisable format required for compatibility with the University CAD system is the current revision of AUTOCAD.
- .3 Component and system software, firmware and configuration files shall also be provided in hard copy and or electronic media form as part of the "construction" package.
- .4 Facilities Operations and Development and UTHVS require that complete and up to date schematic and point-to-point wiring diagrams and service manuals be furnished by the contractor as a part of his final submittal of Service and Instruction Manuals for the project. This information shall be prepared specifically for each component and system prior to construction and included in the project construction documentation (hardcopy and electronic).
- .5 As the project progresses through the construction and commissioning process, an up to date marked up set of drawings shall be kept at site in a secure location under the control of the electrical contractor, prime contractor, or commissioning authority to serve as the Record Drawing Set for the project. Mark-ups to these drawings shall include all changes to the original design as well as a record of all changes and additions made to the design by construction contractor to accommodate interferences and as found conditions. These mark-ups shall be performed by qualified personnel, be complete and reflect good drafting practice. At the completion of the project, these marked up drawings shall be submitted to the original design entity for review and permanent incorporation onto project record drawings. These record drawings shall be provided within 90 days of project completion. At no time shall the university be without up to date marked-up drawings for the project. Usable and complete copies of project as-built's shall be made prior to removing the original marked-up drawings from site, and retained at site for use by the University engineering and maintenance personnel until the final record drawings can be issued and distributed for use.

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

- .6 Facilities Operations and Development and UTHVS require that complete and up to date software and firmware, component configuration files, and source code where applicable be furnished by the contractor as a part of his final submittal for the project within 30 days of project completion. This information shall be prepared specifically for each programmable or configurable component and system included in the project.
- .7 Labeling
  - .7.1 The Contractor, at the time of installation, shall label all major power components using terminology acceptable to UTHVS. Equipment labels shall provide the Name and function of the equipment as well as its power source. When the equipment is made up of two or more separately identifiable devices, sections, or compartments, these too shall be individually labeled. Nomenclature used on the labels shall be consistent with that used on the associated drawings, O&M documents and training materials. All labels identifying major equipment shall be readable from a distance of six feet. All labels providing instruction or used for the safe operation of major equipment shall be readable from a distance of three feet.
  - .7.2 Control devices such as control switches, relays, displays and instruments shown on One Lines, schematics, interconnection wiring diagrams etc. shall be labeled in nomenclature consistent with that used on the drawings.
  - .7.3 Labeling applied for the purposes of Operator safety, equipment protection and system operation considerations is Owner specified and may be applied by the Contractor based on contract documents (drawings or specifications) or may be applied upon construction completion by the Owner or the owner's representative. Regardless, labeling shall be completed prior to release of equipment and systems to Utilities for operation. Refer to Utilities internal procedures for Arc Flash Hazard labeling standards.

### **48 05 02. General Material and Contractor Requirements**

- .1 The Contractor shall specify only Underwriter's Laboratories listed equipment, assemblies, and materials when such items are available and technically acceptable to the design. The equipment and materials shall be installed in accordance with its listing. Equipment and materials shall be selected from a pre-approved Vendor list when available, and subject to UTHVS approval.
- .2 Contractors submitting proposals to provide electrical design or construction services shall be required to demonstrate adequate competency, and recent relevant work history. This requirement applies to the contractor's supervision and work force as well as to subcontractors, their supervision and work force. Work experience, personnel credentials and work references shall be submitted in writing at the request of UTHVS for their review and approval. This requirement applies to all subcontractors as well. No electrical contractors shall be permitted to work on power plant or related facilities that have not established a verifiable record of quality of workmanship, safety and reliability.

### **48 06 00 SCHEDULES**

#### **48 06 01. Schedules (McCracken PP and Smith Sub)**

The following orientations between power supply bus and electrically powered equipment shall be observed without exception. Control power and communication based control system power orientation shall reflect this orientation or be supplied from the Plant UPS.

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

### **.1 400 BUS ORIENTATION:**

#### **.1.1 Bus 400 orientated busses and feeders are:**

- 13.2 KV Bus 401
- 13.2 KV Feeder to 480 Volt Unit Sub 2 and unit Sub 3 [ T2, T3 ]
- 13.2 KV Feeder to 480 Volt Unit Sub 5 [ T 5 ]
- 13.2 / 4 KV Transformer T1400 (North)
- 4160 V Bus 1400, Chiller Bus 89
- FD Fan bus 1401
- Smith Sub 480 V MCC. 2

#### **.1.2 Bus 400 Associated Loads are:**

- Boiler # 1
- Boiler # 3
- Boiler # 8 Future
- Chiller # 1
- Chiller # 2
- Chiller # 3
- Chiller # 5 Future
- Chiller # 8
- Chiller # 9
- Chiller # 10)

### **.2 600 BUS ORIENTATION:**

#### **.2.1 Bus 600 orientated busses and feeders are:**

- 13.2 KV Bus 601
- 13.2 KV Feeder to 480 Volt Unit Sub 1 and unit Sub 4 [ T1, T4 ]
- 13.2 / 4 KV Transformer T1600 (South)
- 4160 V Bus 1600, Chiller Bus 67
- FD Fan bus 1601
- Smith Sub 480 V MCC. 4

#### **.2.2 Bus 600 Associated Loads are:**

- Boiler # 5
- Boiler # 6
- Boiler # 7
- Chiller # 4
- Chiller # 6
- Chiller # 7

Bus and equipment power dependency schedules for Allied facilities and central Chiller Plants are unique to those facilities.

### **48 06 02. Schedules (South Campus Central Chiller Plant)**

#### **.1 BUS 100 C**

5 kV Transformer 1100C  
575 V Unit Sub 1A

## DIVISION 48 -- Electrical Power Generation (and Allied Facilities)

---

- 575 V Unit Sub 3A (future)
  - Chiller # 1
  - Chiller # 2
  - Chiller # 3
  - Chiller # 4
  - Chiller # 7
  - Chiller # 8
  - Chiller # 9 (future)
  - Chiller # 10 ( future)
  
- .2 BUS 200 C
  - 5 kV Transformer 1200C
  - 575 V Unit Sub 1B
  - 575 V Unit Sub 2A
    - Chiller # 1
    - Chiller # 2
    - Chiller # 5
    - Chiller # 6
    - Chiller # 7
    - Chiller # 8
    - Chiller # 11 (future)
    - Chiller # 12 (future)
  
- .3 BUS 300 C
  - 5 kV Transformer 1300C
  - 575 V Unit Sub 2B
  - 575 V Unit Sub 3B (future)
    - Chiller # 3
    - Chiller # 4
    - Chiller # 5
    - Chiller # 6
    - Chiller # 9 (future)
    - Chiller # 10 (future)
    - Chiller # 11 (future)
    - Chiller # 12 (future)
  
- .4 Bus orientations for auxiliary components have their power orientation options aligned with the orientation options of the Chiller drives.
  
- .5 Standby Power System alignment is to Bus 200C as is the Standby feed from West Campus Substation.
  
- 48 06 03. Schedules (East Regional Chilled Water Plant)
  
- .1 PRIMARY SWITCH A (CKT 405)
  - 5 kV Transformer TA powering Bus A
  - 575 V Unit Sub Transformer T1A powering Bus 1A
    - Chiller # 1A
    - Chiller # 1B
    - Chiller # 2A
    - Chiller # 2B
    - Chiller # 3A
    - Chiller # 3B

Via 5 kV Tie

Chiller # 4A  
Chiller # 4B  
Chiller # 5A  
Chiller # 5B  
Chiller # 6A (Future)  
Chiller # 6B (Future)

.2 PRIMARY SWITCH B (CKT 605)

5 kV Transformer TB powering Bus B  
575 V Unit Sub Transformer T1B powering Bus 1B  
Chiller # 4A  
Chiller # 4B  
Chiller # 5A  
Chiller # 5B  
Chiller # 6A (Future)  
Chiller # 6B (Future)

Via 5 kV Tie

Chiller # 1A  
Chiller # 1B  
Chiller # 2A  
Chiller # 2B  
Chiller # 3A  
Chiller # 3B

.3 Bus orientations for auxiliary components have their power orientation options aligned with the orientation options of the Chiller drives.

.4 A third feeder, CKT 505 is aligned to serve as back-up to Primary Switches A and B.

The assignment of motive power, control and instrumentation shall conform to the above described approach for all upgrades, expansions and modifications. Where facilities have UPS supplied busses for low voltage critical controls, critical feeds shall reflect the basic design approach given above for a division of power dependencies so as to avoid losing more than a portion of the powered equipment from a single power source failure. UPS Standby AC sources should be chosen to appropriately address the sustained loss of the UPS normal power, usually a battery/battery charger.

New construction designed to meet redundancy requirements shall have its major equipment motive power and control power dependencies defined and arranged at the Schematic Design stage to support those redundancy requirements.

**48 08 00 TRAINING/TESTING AND COMMISSIONING**

48 08 01. Training

.1 Operator training for routine operation of electrical systems or equipment shall be provided. Training requirements shall be set by the University on a case by case basis. Such training shall establish minimum training hours per shift, of on-site instruction for the daily operation of the system, to be attended by University's designated Operations personnel. All training shall be scheduled by the contractor in coordination with the University's Facilities Operations and



## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

Development, Training Officer, and his designated representatives. Training sessions may be taped for future reference and training by the University.

- .2 In addition to the warranty for labor and materials as specified in General Terms and Conditions: The vendor shall at the request of the University, provide additional technical on-site support for the system during warranty. All support shall be at the request of the University's Director of Utilities or designated representatives.
- .3 The University desires to become self-sufficient and skilled to the point of being able to perform regular preventive maintenance, annual system inspections, remedial maintenance, and small renovations. In addition to the above Training for Operation, and Additional Support During Warranty, the design authority shall evaluate the following Training for System Maintenance categories and OEM manufacturer's standards and establish training expectations in the contract documents for:
  - .3.1 OEM hardware tools and documentation
  - .3.2 OEM software tools and documentation
  - .3.3 OEM training, at the University's FOD Training Center, on the use of the above hardware and software tools, and OEM certificate of "Authorized Warranty Service Technician" or equivalent. All training and diagnostics shall be identical to that as provided and available to the factory authorized service representatives. The training shall allow the University to perform all maintenance and inspection functions. The hardware tools shall include EEPROM programmers using industry standard IBM-compatible desktop PC's. The software tools shall perform on industry standard IBM-compatible desktop PC's, using industry standard MS-DOS or MS-Windows operating systems. The training shall be conducted by the manufacturer's trainers, and shall include classroom hands-on training with instructor and travel. All Training for System Maintenance shall be coordinated with the University's FOD Training Officer and shall accommodate multiple shifts of maintenance personnel.
  - .3.4 The system, devices, and applications, along with OEM training of the University's Operations personnel, shall allow the University to perform the periodic inspection of the systems and equipment provided.
  - .3.5 UTHVS personnel may be assigned to commissioning, check-out and startup support roles for the express purpose of training and familiarization on systems and equipment.

### 48 08 02. Testing

- .1 **FACTORY TESTING:** Factory testing for major equipment and integrated systems shall demonstrate design compliance to procurement and functional specifications. It shall be conducted to appropriate industry standards and include third party testing and verification. The option for Owner acceptance by participation in the testing or through a review of the testing results shall be made available with a minimum of two weeks written notice prior to planned commencement of testing.
- .2 **INSTALLATION QC TESTING:** The contractor shall supply appropriate technically competent support personnel to monitor workmanship and completeness. This shall involve in-line work inspection or audit inspection with rigorous corrective action, follow up and closure on non-conforming work products and methods. Tests and inspections shall include OSU Standards compliance and compliance to good industry practices. Instrument calibration and set-point verification shall be included in the contractors test and inspection planning and execution.

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

The contractor shall supply appropriate technically competent support personnel to test and inspect installations for fitness for service in accordance with Building Design Standards and NETA guidelines.

Testing shall be performed to demonstrate fitness for service of all components. A representative from the FOD Utilities High Voltage Shop (UTHVS) shall witness the testing. Copies of test results shall be provided to FOD through Project Captain.

- .3 **POST INSTALLATION TESTING:** The contractor shall supply appropriate technically competent support personnel to conduct and support a thorough pre-operational testing of all installed systems and components for all modes of operation in accordance with Building Design Standards and NETA guidelines. Testing shall include equipment controls, protective relays and safety interlocks.
- .4 **SYSTEM FUNCTIONAL TESTING:** All systems shall be tested to demonstrate their ability to function as required over the full limits of their normal operational range and for any emergency range as called for in the system design. This testing shall be conducted with the systems and associated equipment installed and operating in their normal mounted orientation, settings and conditions of power supply and environment. This testing may be conducted in an integrated fashion with all system interfaced as designed or may be done piecemeal (overlapping) in a manner that demonstrates acceptable functionality of all interfaces, shared functions and dependencies.
- .5 **INTERLOCK VERIFICATION TESTING:** Once all construction has been completed and all system installation and construction testing completed, the FOD or their appointed agent shall conduct testing designed to validate the proper operation of all system permissives, trips, critical sequences, operator HMI functions and annunciators. An independent testing Service (ITS) may be contracted to work in conjunction with the equipment suppliers' representatives to check out and startup LV switchgear, systems and equipment. A Relay Check-out Organization (RCO), working under direct engineering level supervision is generally required to perform checkout and startup of MV switchgear, systems and equipment.
- .6 **CERTIFICATION PROCESS:** The Owner requires all test reports and records as well as individual certifications of any and all test authorities, the manufacturer or independent testing agencies be provided for review and acceptance. These records along with supporting documents showing acceptable resolution of open items, test discrepancies, failures and repair, retesting etc. will serve as the basis for certifying equipment for service by the Owner.
- .7 **ACCEPTANCE PROCESS:** OSU Utilities, as the recognized authority having jurisdiction (AHJ) for Utility Plant equipment and distribution systems and facilities shall inspect for safe and conformant operation. The inspection shall follow due process and demonstrate due diligence in the review and acceptance of all installations and processes relating to quality, completeness and conformance to applicable Codes and Standards. Acceptance will be granted only after the inspection process has been completed to the AHJ's satisfaction and all documentation has been received, reviewed and accepted.

In the case of nonutility facilities, it is the standing protocol for OSU Utilities to defer to the ODIC for all low voltage inspections. The placement of the ODIC inspection sticker on low voltage switchgear is a requirement for primary service energization and Utilities relies on a successful completion of this inspection as Utilities performs only a cursory "housekeeping" inspection of the low voltage gear and verifies conformance to the BDS DIV 33 requirements that pertain to that main switchgear.

In the case of all Utility Facilities where Utilities is the AHJ, all inspections for both medium and low voltage systems are the responsibility of Utilities. On large projects, this inspection

may be conducted for Utilities by an Independent Testing Agent. As noted above, these low voltage designs are not required to conform to the NEC. Hence the placement of an ODIC inspection sticker is not prerequisite to switchgear energization. However, UTHVS will in most cases require the ODIC inspection be present before the equipment is energized. This is to avoid contractor confusion and recognize the participation of ODIC.

Portions of the low voltage installation do however generally conform to the NEC. These portions are typically installations such as 120/208 systems for lighting and the like which are installed to the design documents but use industry installation practices administered by the electrical contractor and QC'd by that organization. From time to time, as a courtesy to OSU, the ODIC inspectors will perform an inspection of these installations and provide an inspection sticker to document that inspection. This sticker is not considered by Utilities to be an inspection based on the University BDS. OSU Utilities relies on the successful completion of the appropriate portions of the electrical checkout and testing program conducted by Utilities staff and/or the Independent Testing Agent for their release to energize electrical distribution systems and equipment.

- .7.1 Tests must be conducted in accordance with University requirements and shall be witnessed by representative(s) of UTHVS
- .7.2 Medium and low voltage cable testing shall comply with NETA and AEIC guidelines with the following exceptions:

Hi-pot testing on 133% EPR insulated 13,200 volt system cable shall be a 42,000 volt DC High Pot performed by an approved test instrument witnessed by the UTHVS. The 42,000 volt High Pot test is applied in 7,000 volt intervals of one Min. duration with a 5 minute sustained interval at 42,000 volts. High Pot testing of existing installed primary cables is limited under normal conditions to 10,000 volts This 10,000 volt DC High Pot is applied gradually with a sustained duration at 10,000 volts for five minutes. The 42,000 test shall only be done after pulling, termination and splicing of new cables, but before splicing to the existing cables. A maximum of 10,000 volts dc high pot test shall be applied for all installations after splicing to existing cable.

Hi-pot testing on shielded 133% EPR insulated 4160 volt system cable shall be a 28,000 volt DC High Pot performed by an approved test instrument witnessed by the UTHVS Utility High Voltage Shop. The 28,000 volt High Pot test is applied in 7,000 volt intervals of one Min. duration with a 5 minute sustained interval at 28,000 volts. High Pot testing of existing installed primary cables is limited under normal conditions to 19,000 volts This 19,000 volt DC High Pot is applied gradually with a sustained duration at 19,000 volts for five minutes. The above limits apply to cables without the presence of a surge suppressor.

Hi-pot testing for 600 volt circuits may be elevated to a maximum 2500 VDC 1 minute duration for certain critical control components as identified by Utility High Voltage Services on a case by case basis.

- .7.3 Commissioning Plan: The engineer, or commissioning agent, will provide a commissioning plan for all systems and associated devices. The Commissioning plan will include a detailed checklist to commission each item installed by the project. Each item will be commissioned by qualified professionals and factory trained personnel. Each device along with its electrical and process field connections will be field verified end to end. Each item shall be functionally tested to demonstrate the installation meets the design's technical and operational requirements to the satisfaction of The University, Utilities Department.

.7.4 Field calibration records: All transmitters and positioners will be field calibrated by personnel trained in field calibrations. Each calibration will be documented on a calibration sheet. Calibration sheets will have as a minimum: Tag Name, Description, Location, Process variable, Range, Calibrator type and model with last date of certified calibration, and calibration data showing As-Found and As-Left checks. Instrument calibration checks will be 0-25-50-75-100 percent of range recorded on the calibration sheet.

All Protective relays will be field calibrated by personnel trained in field calibrations. Each calibration will be documented on a calibration sheet. Calibration sheets will have as a minimum: Tag Name, Description, Location, and recorded on the calibration sheet.

**48 09 00 INSTRUMENTATION & CONTROL FOR MAJOR ELECTRICAL PLANT EQUIPMENT**

Note: Refer to 40 90 00 for requirements relating specifically to Process Control and monitoring for fluid systems and components.

48 09 10. Design Requirements for Instrumentation and Control for Power Plant and Auxiliary Equipment

.1 GENERAL: This section addresses the control of major substation and distribution system electrical equipment such as switchgear, large power transformers and auxiliary support systems and equipment such as station battery systems, automatic transfer controls medium and low voltage motor control centers and transfer switches. The requirements contained in this section are to be used in conjunction with the requirements of other BDS DIV 40 and 48 sections giving detail requirements relating to specific equipment and systems and their wiring and physical installation. Included in this section are requirements for controls using solid state and electromechanical relays, programmable logic controllers, motor starters, transfer switches, medium and low voltage switchgear, custom manufactured package systems, 125 v DC systems, power transformers of all sizes.

This section addresses the principal design criteria for the control of this equipment. The instrumentation referred to in this section is the power instrumentation required for the operation, testing and maintenance of this equipment such as ammeters, voltmeters, indicator lights, current transformers, potential transformers, shunts, meters, data acquisition systems etc.

.2 OPERABILITY: Controls shall be designed to address the range of normal and emergency service requirements relating to the equipment and systems being controlled. If controls are limited to manually initiated control functions, they should conform closely to conventions and practices widely used elsewhere for similar systems and equipment. Instrumentation needs to be present (at or near the control station location) to assist the operator in determining the effectiveness of the control actions taken. If the controls are automatic, they should contain features that provide status on the controls, the process and or parameters being controlled. These features should not depend on the same instruments providing the control variable inputs to the automation. Where automation has been applied to supplant manual control, the capability of some basic level of manual override should be provided along with the means for the operator to assess the situation and receive feedback on any manual operations undertaken ( example: an E stop with indication, a speed control pot with speed indication).

.3 MAINTAINABILITY: Controls should be designed to facilitate planned maintenance for the systems and equipment being controlled. An example of this would be the inclusion of a

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

manual control station to facilitate draining or filling operations or system post maintenance startup. Automatic controls should be provided with information relating to the availability of system equipment when it has been removed from service for maintenance. LOTO considerations relating to local power disconnects, power source lock-out, etc. must be accommodated.

- .4 **CONSTRUCTABILITY:** Controls must be designed in conformance with the physical constraints of the facility. Control stations, cabinets, panels and compartments must be designed to facilitate cable access and provide adequate areas for orderly field cable marshaling and termination. Since the standards require the use of multi-conductor color coded jacketed and labeled cables with wire sizes in the AWG 10 to 14 for control conductors and AWG 16 for some instrumentation cables, cable management requires careful planning and design.

- .5 **TESTABILITY:** Controls need to be designed to facilitate planned preoperational and post maintenance testing for the systems and equipment being controlled. This may mean designing the controls with built in test modes of operation, or it may simply involve designing the controls to facilitate LOTO depending on system complexity and the various types of testing to be accommodated.

Automatic controls should be provided with information relating to the availability of system equipment when it has been removed from service for maintenance and testing.

- .6 **HUMAN FACTORS**

- .6.1 **Accessibility:** Control stations need to be located where they can be conveniently reached and where they will not be in the way of routine or planned maintenance. Mounting control stations on equipment or in areas where access could be restricted because of ambient noise, high temperature or a higher than normal risk of steam or water leaks should be avoided.

- .6.2 **Lighting:** Control stations need to have lighting adequate to support the operator actions planned as well as sufficient access and egress lighting. Where task lighting cannot be supplied at high enough levels to accommodate operator needs, displays should be designed with back lighting or the control station should have its own source of task illumination.

- .7 **HUMAN MACHINE INTERFACE (HMI)**

- .7.1 **Type:** The HMI selected should be appropriate to the task being performed. Hard wired controls for simple control actions, touch screens for more complex tasks, and where a visuals or process displays would be helpful, analog displays for displaying rapidly changing parameters, digital where slow moving parameters are involved, where there is a wide range in the variable, or where precision is needed.

- .7.2 **Information displayed:** The information displayed at a control station should be compatible with and adequate for the control actions planned for the station. Information displayed should be organized in a logical manner in relation to the control devices. Clutter should be avoided.

- .7.3 **Controls available:** Control devices available at a control station should be limited to what is required for the intended operations. Main or frequently used controls should be located centrally within the easiest reach of the operator. Less frequently used control should be positioned in their own functional grouping, out of the central control area. Some controls that are not intended for normal control operations such as E-stops, or devices that would cause serious disruption if inadvertently operated

should be placed in an accessible location but away from the more frequented areas of the control station. Functional grouping of controls is preferred. Clutter should be avoided. Guards should be provided or the “two independent action” rule should be employed where inadvertent operation could have grave repercussions.

.8 ENVIRONMENT

- .8.1 Temperature, Humidity: Apply control components and locate control stations where they will not be exposed to adverse ambient temperatures, humidity and dew point cycling if at all possible. Enclosures should be designed with cabinet heaters for high humidity environments and should have a NEMA enclosure design consistent with the environment.
- .8.2 Water hazards: Where water hazards could exist, control station equipment should be water tight or resistant. Care must be taken to insure that cable access is from below or low to the side. Where moisture intrusion is considered a risk, the control cabinet should be equipped with a bottom drain point that is screened to exclude insects and rodents.
- .8.3 Proximate hazards: Locate control stations only where there is minimal risk of exposure to proximal hazards such as steam leaks, rupture diaphragms, safety valves, electrical Arc Flash, falling or tripping. Access to control stations should not involve climbing or the use of any temporary structures, ladders or scaffolding.

.9 FAILURE MODES AND EFFECTS ANALYSIS

- .9.1 Design practices: The Design shall include a formal control plan that identifies and addresses all the key design features that define or impact on the design of the control system.

Discussion of intended operation:

- Automatic features
- Manual features
- HMI types and locations
- Design features
- Power Dependency
- Failure modes
- Tripping
- Interlocking
- Alarming

The design of the controls should observe to the extent practicable established and standardized control practices so as to benefit from past experience and lessons learned. The application of control components should be standardized around a limited set of approved components and manufacturer product lines to simplify spare parts stocking and training. Control circuit designs should be replicate between similar pieces of electrical power equipment and between similar systems.

- .9.2 Failure modes

Control circuit failure modes should be identified and evaluated. Predominant failure modes should be accommodated by designing adequate annunciation and or indication to assure that the operator is aware of the failure and can take appropriate operator action. The impact of individual component failures should be minimized by

applying the component in a manner so that the dominant failure mechanism would have the least significant impact on the system operation or potential for equipment damage.

Power dependencies should be identified and evaluated. Power sources should be selected to conform to the overall power dependencies of the prime movers in the system. The choice of control voltage should be based on the characteristics of the control power sources available.

Battery backed 125 vdc is the most reliable source but designs powered from battery backed 125 vdc should be energize to actuate, normally de-energized and be capable of being de-energized with critical systems in operation without the controlled system tripping. 125 vdc is the preferred source for electromechanical controls that must operate under blackout conditions and when system ac power is lost.

120 vac inverter backed control is the preferred power for ac powered electronic controls and instrumentation that must remain in service independent of the availability of system ac power. Inverter use should be restricted to this type of load and under no condition should an inverted backed ac source power motors or load with significant startup transients with the possible exception of switching type power supplies. Inverter sources are inherently current limiting, so the exposure of these circuits to shorts or grounds is a concern. This concern can be mitigated somewhat by providing a solid state transfer switch to an alternate source of ac with greater fault support capacity, and the appropriate selection of inverter output distribution panel circuit breakers. If electromechanical control devices such as relays and solenoids are powered off an inverter backed source, coil suppression is recommended.

Diesel backed ac is the preferred source for controls that can sustain a momentary or short term loss of ac power and still function acceptably once power is restored. In the case of Emergency Diesel Generator power, restoration usually occurs in around ten (10) seconds. In the case of Standby generators, restoration may take as long as a minute or more.

### **.9.3 System effects**

The system effects of a control system or component failure need to be assessed and addressed in the control design. Control failure modes must be compatible with system and component preferred failure states. A fail closed air operated valve will generally require a solenoid and control circuit design where a solenoid coil or control power failure will result in the valve closure as well. A circuit breaker control which is designed to open and close the breaker is generally designed to fail as is. Safety considerations are another factor to be considered in control design. A failure in the trip circuit of a circuit breaker should remove power to both the close and trip portions of the breaker control circuits. This is a useful safety feature to avoid the possibility of closing a breaker whose trip circuit has already failed. Likewise, powering the closed indication of a circuit breaker by having the closed indicator light powered from the trip circuit through the trip coil of the breaker insures that the loss of closed indication on breaker closing will alert the operator to a possible abnormal situation with the breaker.

#### **Note:**

Charging power for an electrically charged circuit breaker should never be drawn from the trip circuit of the breaker if the charging motor is designed to go through its charging cycle after the breaker closes. This introduces a failure mode that would in effect be the equivalent of closing a CB with a failed trip circuit.

.9.4 Situational awareness

Particular care must be taken to insure that the instrumentation provided with controls provides adequate situational awareness for the operator to assess the effectiveness of automatic controls and to monitor manual control actions. Instruments and displays provided for monitoring the condition of the controlled system generally should not share signals with the instruments controlling the system. As a general rule instrumentation that the automatic control function relies upon for its control action should be independent of the instrumentation relied upon to determine effectiveness of the automatic controls or depended upon to take manual control action.

.9.5 Recovery and use of lower tier controls

It is customary to provide echelon control to complex systems. Echelon control involves applying controls in layers. A system may have a master control that provides system level commands from a system operator or automatic dispatch control. This Master control may control only that one system or a variety of systems to coordinate their individual automatic operations. A system then may have subsystems that have their own automation and so on. Each of these layers may have both automatic and manual control modes.

As a general rule, a system or group of systems that share an echelon control architecture should have their controls designed to allow higher echelon automation to automatically detect the loss of lower echelon automation and take appropriate compensatory action to address system control needs including operator situational awareness and appropriate adjustment of lower tier operating modes, set points and limits.

Echelon controls should not be applied where loss of a subsystem's automation will result in a wholesale loss of system automation and wholesale reversion to manual control. Loss of automatic control at any level should always be readily recoverable by skilled operator action or result in placing the subsystem in a safe condition or operational mode with minimum disruption to the remainder of the control system.

48 09 20. General Requirements for Control and Instrumentation Circuits and Enclosures

Note: Refer to 40 90 00 for requirements relating specifically to Process Control and monitoring for fluid systems and components.

- .1 AC and DC control circuits shall not be run in the same control cable. Low level instrument cables shall not be run in conduit or in tray shared by power, or 110 vac, 125 vdc control cables.
- .2 All control panel, control cabinet and switchgear wiring No. 10 AWG and smaller shall be landed on OSU Utility approved terminal blocks. Stranded wire termination shall be with approved ring type solid un-insulated barrel design. No more than two wires shall be terminated on any screw type terminal point. Thread on wire nuts or split bolt connectors are not permitted. In-line control wire splices are not acceptable for new installations.
- .3 Control cable butt splicing for modifications or upgrades is permitted with prior approval of UTHVS. Butt splices in control and instrument cable conductors shall be made with the appropriate sized butt connectors and insulated with electrical tape or approved heat shrink tubing with appropriate shimming.
- .4 All control components are to be secured firmly to their supporting structures. Self-adhesive fasteners and thermo plastic fasteners are not acceptable.



## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

- .5 All cables and wiring that is field run to control panels or equipment enclosures shall be terminated on UTHVS approved terminal blocks. In general, termination of jacketed multi-conductor color coded cables #14 AWG and larger directly onto high density terminal blocks or termination modules is not acceptable.
- Landing field wires directly on serviceable components is not permitted. Small local control stations may be excluded from this requirement. Termination of stranded wire to high density terminal blocks or terminal blocks that employ pressure type terminal clamping shall be via ferrule. In instances where the use of ferrules is not practical, the wires are to be stripped to allow enough exposed conductor to permit full penetration into the terminal and tinned to form a solid conductor. Terminations made to terminal blocks that employ a pressure type terminal shall have conductor insulation extend up to the block and not show exposed conductor. High density screw type terminations, where permitted, shall employ insulated lugs where necessary to maintain adequate electrical clearance between adjacent terminations
- .6 All current transformer secondary circuits shall be wired through shorting type terminal blocks.
- .7 All control cabinet and enclosure control wiring shall be dressed neatly, bundled and laced. Heavy duty UV resistant tie-wraps are an acceptable method of lacing. Panduit may be used to organize and support control wiring in high density applications where expressly approved by UTHVS. No field cables shall be run along with cabinet wiring in Panduit and field cable jackets shall not be stripped back and the conductors run with cabinet wiring in Panduit. Cable and wire bundles shall be supported at regular intervals. Generally lacing to cabinet mounted tie points is an acceptable approach. Self-adhesive tie-downs are not acceptable. All control cable bundles shall be routed away from power circuits, crossing only at right angles.
- .8 Every reasonable effort shall be made to separate 480 and 575 V equipment and circuits from control wiring. 480 V components and wiring shall be mounted separate from control components and provided separate access. Control components accessed for operations or maintenance shall not share the same enclosure with the power switching components or exposed power wiring without adequate protection from accidental contact by personnel or tools.
- .9 In instances where low voltage (125 volts or less) control components and wiring must be housed in a common enclosure with power circuits (220 volts or above), exposed power circuit conductor surfaces shall be provided with a barrier to reduce the likelihood of accidental shock or burn.
- .10 The preferred configuration for the separation of power and control is to have the power cabinet separate and to the side of the control cabinet. If this is not possible, the power cabinet and components should be mounted above rather than below the control cabinet or panel. Points of interface between control and power circuits such as control transformers shall be located with the power equipment. Secondary (control) fuses shall be located in the control area, not on the control transformer or in the power area.
- .11 Adequate consideration shall be given to the operating temperature environment for temperature sensitive components. Electronics shall be mounted below the mid-plane of their housing enclosure. Sources of heat generation such as transformers and power supplies shall be mounted above, not under temperature sensitive equipment and enclosures shall be sized to operate closed without forced ventilation or the need for fans or filters. A maximum of 10° C temperature rise is allowed on enclosures for equipment rated 60° C or less. This shall be verified by heat run test or analysis and the rise shall be measured at the top of the enclosure.

## **DIVISION 48 -- Electrical Power Generation (and Allied Facilities)**

---

- .12 All control cables entering control cabinets and enclosures shall be secured by their jackets to a cabinet or enclosure support to provide a strain relief for the cable wire terminations. Field cables entering a cabinet shall not be bundled so as to obscure cable identifying labels. Cable identification labels shall be visible without removing equipment or disturbing the cable.
- .13 Control wiring traversing hinges or other forms of flexible constructions shall be high-stranded and shall traverse the area of bending normal to the plane of rotation so as to impart a twisting rather than a bending motion to the cable or wire bundle.
- .14 GENERAL WIRING REQUIREMENTS for Control Circuits  
(See section 48 03 03)
- .15 INSTRUMENTATION WIRING (300 volt class and below)
  - .15.1 Use of No. 16 AWG XHHW2 for all analog instrument circuit wiring (<50 V) is required.
  - .15.2 Use of manufacturers approved plenum rated cable for all communications and digitally based signal cables is required.

### **48 11 00 GENERATION (BULK, PEAKING, AND STANDBY)**

(Reserved for future generating capacity additions)

### **48 19 00 POWER PLANT ELECTRICAL EQUIPMENT**

(Reserved for Equipment Application Specifications)

48 19 01. Fusing and protective Devices (future)

48 19 02. Generic Specifications (future)

.1 MOTORS

.2 TRANSFORMERS

.3 SWITCHGEAR

.4 DISTRIBUTION PANELS

.5 VFDs

.6 SOFT STARTERS

.7 MV MCCs

.8 IINVERTERS

.9 CONTROL PANELS

.10 MOTOR CONTROL CENTERS AND LV STARTERS

Note: While this section of DIV 48 remains a work in progress, UTHVS maintains a supplemental Planning and Design Guide. This guide contains engineering guidance relevant to the above equipment design and application.

48 19 03. Models and Studies

The University (UTHVS) maintains current fault, coordination and Arc Fault studies for Main substations, the MV distribution System and all central facilities. These models and studies are available to Engineers performing work on the MV system and any of the Utility operated and maintained facilities. Any Engineered changes to these facilities or the MV system of sufficient scope to impact any of these models or studies will require the studies or models be updated by the Engineer. Models are kept current on a periodic basis by UTHVS and are updated as needed for small changes by UTHVS.

## APPENDIX A

2006 Edition, Published January 1, 2006; Document Revision Date: June 30, 2016

### BUILDING AUTOMATION SYSTEM PART 1 GENERAL

#### 1.01 SCOPE

- A. The intent of this Appendix is to give guidance to the A/E for specifying a Building Automation System for new and renovated buildings. This Appendix may not be applicable to all renovation projects; however, the design approach should be confirmed with the OSU Project Manager and the FOD Building Automation Department. The long term goal is to provide the building with a complete Direct Digital Control (DDC) Temperature Control System to automatically control the operation of the entire Heating, Ventilating and Air Conditioning System and monitor and/or control auxiliary systems as applicable to the project scope of work. The new Building Automation System shall fully integrate into the existing district wide Building Automation BACnet network. The required integration shall include the creation of custom graphics and the compilation and display of all devices and objects on the existing Delta Controls Operator Workstation (OWS) and Web server. All graphic displays will reside on the existing Delta Controls OWS and be modified accordingly. In addition, the system shall perform the said integration through the use of BACnet/IP communications (Annex J only). BACnet over Ethernet will not be supported for district wide communications. Failure to mention any specific item or device does not relieve the Contractor of the responsibility for installing or integrating such device/peripheral in order to comply with the intent of the Drawings or this Specification.

**Student Life: existing network for Student Life buildings is Johnson Controls ADX. The University (Student Life) will furnish the necessary Johnson Controls devices (NAE panels) for integration into the SL server. The DDC Contractor shall install the panels and provide all integration with the SL server.**

- B. Building Automation System (BAS) Contractor shall provide:

1. A fully integrated and fully programmable BACnet building automation system (BAS), UL listed (UL916 and UL864 If applicable), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, as manufactured by Delta Controls by BCI, Siemens or Automated Logic by Pittsburgh Corporate Branch or an approved equivalent manufacturer. The A/E must submit the proposed "equivalent manufacturer" during the Schematic Design Phase to the OSU Project Manager for approval by the FOD Building Automation Shop.

**Student Life: Delete Siemens and add Johnson Controls and Trane as approved equivalent manufacturers. Delete Pittsburgh Corporate Branch and add EMCOR as approved installer for Automated Logic.**

2. A UL864 listing shall be required for all controllers that are utilized in a smoke control sequence and as necessary to meet or exceed all national and local codes. In addition, UL864 devices and non UL864 shall not be permitted on the same network segment unless the devices are separated with a UL864 Ethernet switch. All MS/TP network segments shall be consistent with its UL864 or non UL864 implementation. In other words, there shall not be UL864 product and non UL864 product on the same MS/TP network segment.
2. Necessary conduit, wiring, enclosures, and panels, for all DDC temperature control equipment and devices. Installation shall comply with applicable local and national codes.
3. All components and control devices necessary to provide a complete and operable DDC system.

4. All final electrical connections to each stand-alone DDC Controller. Connect to 120VAC power as provided by the Division 26 contractor, to be terminated within 5 feet of the DDC Controller. [Note: A/E clearly defines the scope of work for each Prime Contractor in the Contract Documents.]
5. BAS Contractor shall be responsible for all electrical work associated with the BAS control system and as defined In the Contract Documents. This BAS control wiring shall be furnished and installed in accordance with the Electrical requirements as specified in Division 26, the National Electric Code, and all applicable local codes.
6. Surge transient protection shall be incorporated in design of system to protect electrical components in all Building Controllers, Advanced Application Controllers and operator's workstations. Provide an external protection device listed under UL 1449 with minimum clamping voltage of 130 VRMS and surge current capability of 22,500Amps for all custom fabricated control panels (all main system components (i.e., AHUs, Chillers, Boilers, etc.).
7. All 120V and low voltage electrical control wiring exposed throughout the building shall be run in conduit in accordance with the Electrical requirements as specified in Division 26, the National Electric Code, and all applicable local codes. All low voltage wiring that is concealed in accessible ceilings may be run in plenum rated cable per the National and Local Electrical codes.
8. All 24VAC power required for operation of the BAS shall be by the BAS Contractor and shall be limited to 100 VA per the aforementioned codes. Any 24VAC power link that exceeds the 100 VA rating must be installed in conduit per Division 26 and all applicable codes, regardless of the nature of the installation.
9. BAS Contractor shall provide programming modifications necessary to fine tune sequences during commissioning and through the warranty period of system and for an additional 12 months, at no extra cost to The Ohio State University.

C. HVAC Contractor provides:

1. All wells and openings for water and air monitoring devices, temperature sensors, flow switches and alarms furnished by BAS Contractor.
2. Installation of all control valves as per the contract drawings. The temperature control contractor is not responsible for the incorrect installation of any domestic, hot or chilled water control valves.
3. Installation of all dampers and adjacent access doors for smoke; outdoor air, return air, exhaust air, and ventilation dampers.
4. All package unit control panels including but not limited to, factory boiler panels, factory chiller panels, refrigerant monitors and specialty interface modules required for BACnet compliance.

D. Electrical Contractor provides:

1. Electrical Contractor shall provide dedicated 120 volt, 20 amp circuits and circuit breakers from normal and/or emergency power panel for each DDC Controller. Run power circuit within 5 feet of equipment installed and connected by BAS Contractor.
2. Electrical contractor will also provide smoke detector and smoke damper interlock and power wiring for all life safety applications.

**E. General Product Description:**

1. The building automation system (BAS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection utilizing the BACnet protocol.
2. The building automation system shall consist of the following:
  - a. Stand-alone peer-to-peer Building Controllers with 32 bit processors, a minimum of 2 MB of flash memory and 10 bit A/D converters. Ethernet connectivity is required for all Building Controllers.
  - b. Stand-alone peer-to-peer Application Controllers with 32 bit processors, a minimum of 1 MB flash memory and 10-bit A/D converters. Ethernet or MS/TP connectivity will be permitted for all Application Controllers.
  - c. Portable operator's terminal(s)
  - d. Provide seamless interconnection to the existing Delta Controls central graphic workstation, and build Delta Controls standard and customized graphics displays in accordance with the existing formats. If the BAS controls contractor is unable to build the graphics displays (FOD Building Automation has final say whether or not the displays meet the University Standards) then the BAS controls contractor must sub-contract the displays with Delta Controls BCI at their own expense.
  - e. All BACnet intrinsic alarming shall be disabled. All alarming shall be setup in the existing Delta Controls central graphic workstation. If the BAS controls contractor is unable to set up the alarms (FOD Building Automation has final say whether or not the alarms meet the University Standards) then the BAS controls contractor must sub-contract the set up of the alarms with Delta Controls BCI at the expense of the BAS controls contractor.
3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Building Controllers, Application Controllers, expansion modules and operator devices.
4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices. Alarm management and data collection that requires a single mechanism for user notification or viewing is strictly prohibited.
5. All Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central processing device (peer-to-peer). All Controllers shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

**F. System Lifecycle Support**

1. BACnet Field Devices: Manufacturer shall provide product updates for the lifecycle of the installed DDC hardware at no additional cost to the University. Manufacturers shall provide software tools, licensing, and training necessary for the University's field technicians to deploy and install updates. Updates shall include all patches, firmware, and software revisions for the lifecycle of the hardware or until the manufacturer no longer provides support for the product. Updates shall be available to all devices on the existing

district wide Building Automation BACnet network so that all facilities with like hardware are running on the same firmware and software revisions. The requirement for these updates includes, but is not limited to, products with embedded OS, PLC's, building level controllers, advanced application controllers, application specific controllers, unitary controllers, and component interfaces.

2. Server Frontend Applications, Data Historians, and BACnet Advanced Operator Workstations: Manufacturers shall provide product updates and licensing for the life of the application at no additional cost to the University. Manufacturers shall provide software tools, licensing, and training necessary for the University's field technicians to deploy and install updates. Updates shall include all patches, service packs, security updates, and software revisions. If newly installed hardware is no longer supported by the application, the manufacturer shall upgrade the application to the most current version. If the operating system on the machine running the application has reached the end of its lifecycle (e.g., Windows Server 08R2 or Windows 7), then the manufacturer shall provide software and licensing for the application to run on a modern operating system.

## 1.02 RELATED WORK

### A. Specified elsewhere:

1. \_\_\_\_\_ - Sequence of Operation
2. \_\_\_\_\_ - Variable Speed Control
3. \_\_\_\_\_ - Basic Mechanical Requirements
4. \_\_\_\_\_ - Motors
5. \_\_\_\_\_ - HVAC Pumps
6. \_\_\_\_\_ - Boilers
7. \_\_\_\_\_ - Chillers
8. \_\_\_\_\_ - Cooling Tower
9. \_\_\_\_\_ - Terminal Heat Transfer Units
10. \_\_\_\_\_ - Air Handling Units
11. \_\_\_\_\_ - Testing, Adjusting and Balancing
12. \_\_\_\_\_ - Basic Electrical Materials and Methods
13. \_\_\_\_\_ - Equipment Wiring

### B. Materials furnished by the BAS contractor, but installed by others:

1. BAS Contractor to furnish the following to the Heating, Ventilation and Air Conditioning Contractor for installation by the HVAC contractor:
  - a. Control valves and temperature sensor wells for wet systems
  - b. Location of all wells and openings for temperature, pressure, and flow sensors for pipe systems

- c. Control dampers for air systems
- d. Variable Frequency Drives
- e. Location of all ducts and openings for temperature, pressure, flow, and humidity sensors for air systems.

### 1.03 QUALITY ASSURANCE

- A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- B. Install system using competent workers who are fully trained and factory certified in the installation of temperature control equipment. The factory certified diplomas shall be readily available at the request of the owner or A/E engineer.
- C. The complete installation and proper operation of the Building Automation Controls System shall include debugging and calibration of each component in the entire system and shall be the single source responsibility of supplier. The BAS must be supplied and installed by the same controls contractor. Only Factory Authorized Distributors will be considered for installation. The letting of separate contracts by the prime HVAC Contractor for the Control System and a separate contract for its installation by a third party installer is strictly prohibited.
- D. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
- E. All electronic equipment shall conform to the requirements of FCC Regulations, Part 15, Subpart B, Class A, governing radio frequency electromagnetic interference, and be so labeled.
- F. BAS shall comply with, and be listed at time of bid for the following Underwriters Laboratories Standards:
  - 1. UL 916 for Energy Management Equipment, per category PAZX for Energy Management Equipment.
  - 2. UL 864 for Control Units for Fire-Protective Signaling Systems, per category UUKL for Smoke Control System Equipment.
- G. Design and build all system components to be fault-tolerant.
  - 1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3-Hertz variation in line frequency.
  - 2. Static, transient and short-circuit protection on all inputs and outputs.
  - 3. Protect communication lines against incorrect wiring, static transients and induced magnetic interference.
  - 4. Network-connected devices to be AC-coupled or equivalent so that any single device failure will not disrupt or halt network communication.
  - 5. All Building / System Controllers shall have real time clocks and data file RAM with battery and SRAM backup.
  - 6. All controllers shall be EEPROM, flash driven.
  - 7. The BAS Installer shall have a competent and factory certified Project Manager who is able to answer field questions, is aware of all schedules and schedule changes, and is



responsible for the BAS Installer's work and the coordination of their work with all other trades. This Project Manager shall be available for on site and shall respond to design, programming, and equipment related questions. Failure to provide the above services shall be considered a substantial breach of Contract Documents.

#### 1.04 SUBMITTALS

- A. Submit 10 complete sets of drawings showing the kind of control equipment for each of the various systems and their functions, along with indications on the drawing of all original setpoints and calibration values, and setup parameters, and sequence of operation of the automation system. **These drawings shall be submitted for approval to the A/E and FOD Building Automation**, together with a complete brochure describing the equipment and their functions and operation. Include all application software documentation (actual programs or their job-specific flow charts) with DDC system and schedule a review meeting with OSU and the A/E at least two weeks before installation and start up.
  - 1. Manufacturer's Product Data:
    - a. All equipment components
  - 2. Shop Drawings:
    - a. System wiring diagrams with sequence of operation for each system as specified.
    - b. Submit manufacturer's product information on all hardware items along with descriptive literature for all software programs to show compliance with specifications.
    - c. System configuration diagram showing all panel types and locations as well as communications network layout and workstations.
- B. Where installation procedures, or any part thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the A/E prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

## PART 2 PRODUCTS

#### 2.00 BACnet CONFORMANCE

- A. The Building Automation System (BAS) contractor shall supply a BACnet (ANSI/ASHRAE 135-2004) compliant system. Each device category and its required compliance are listed below under sections F-H. BACnet compatible systems that employ the use of proprietary 'gateways' will not be accepted unless otherwise noted.
- B. The BACnet system shall be capable of Internet Protocol (IP) communications. BACnet/IP or Annex J will be considered the basis of design. All other configurations must be submitted prior to bid, in writing, for final approval. These configurations shall include but not limited to, Annex H or third party BACnet tunneling routers.
- C. The primary Local Area Network (LAN) shall be based upon the ISO 8802-3 Ethernet standard and will be required for all Building Controllers, System Controllers and Operator Work Stations. The use of MS/TP communications for interconnecting the said devices is strictly prohibited. The installation of all Ethernet wiring, accessories, and connectors shall conform to the ISO standard and/or guidelines identified herein. The preferred connection media shall be Category 6, Unshielded Twisted Pair (UTP) wire. The maximum single network run shall not exceed more

than 100 meters. If additional distance is needed, the use of fiber or switches (not hubs) may be approved in special circumstances. However, the 'cascading' of more than 3 switches on a single segment will not be accepted. The BAS system may utilize the customer's Local Area Network (LAN) provided the bandwidth consumption is less than 10% of the total network bandwidth. Under no circumstances, shall the customer's LAN be subject to failure and/or abuse. In efforts to decrease liability, all BACnet devices that reside on the LAN must support the BACnet Broadcast Management Device (BBMD) scheme. Multi-casting or Global broadcasting will not be permitted without the use of a BBMD.

- D. The secondary or sub-network shall utilize the Master-Slave/Token-Passing protocol, as acknowledged by the ANSI/ASHRAE 135 standard. Proprietary RS-485 or equivalent links will not be considered unless otherwise noted. The MS/TP link shall operate at a 38.4 Kbps minimum, and utilize no more than 2 repeaters in any instance. Multi channel repeaters will not be permitted.
- E. The use of proprietary gateways to transmit input/output data, and/or related information, must reside on the Ethernet LAN and be approved, in writing, prior to the bid.
- F. **Building Controller Conformance (BC):** The building controller must be certified and listed by BTL (BACnet Testing Laboratory) under Device Profile B-BC (Annex L of the BACnet standard) with support of the following BIBBs:

*Alarm and Event Management BIBBs*

AE-ACK-B, AE-ASUM-B, AE-ESUM-B, AE-INFO-B, AE-N-A, AE-N-E-B, AE-N-I-B

*Device Management BIBBs*

DM-BR-B, DM-DCC-B, DM-DDB-A, DM-DDB-B, DM-DOB-A, DM-DOB-B, DM-OCD-B, DM-RD-B, DM-TM-A, DM-TS-A, DM-TS-B, DM-UTC-A, DM-UTC-B

*Data Sharing BIBBs*

DS-COV-A, DS-COV-B, DS-COVU-A, DS-COVU-B, DS-RP-A, DS-RP-B, DS-RPM-A, DS-RPM-B, DS-WP-A, DS-WP-B, DS-WPM-B

*Network Management BIBBs*

NM-CE-A, NM-CE-B

*Scheduling BIBBs*

SCHED-A, SCHED-E-B, SCHED-I-B

*Trending*

T-ATR-B, T-VMT-E-B, T-VMT-I-B

- G. **Advanced Application Controller Conformance (AAC):** The AAC must be certified and listed by BTL (BACnet Testing Laboratory) under Device Profile B-AAC (Annex L of the BACnet standard) with support of the following BIBBs:

*Alarm and Event Management BIBBs*

AE-ACK-B, AE-ASUM-B, AE-ESUM-B, AE-INFO-B, AE-N-E-B, AE-N-I-B

*Device Management BIBBs*

DM-BR-B, DM-DCC-B, DM-DDB-A, DM-DDB-B, DM-DOB-A, DM-DOB-B, DM-LM-B, DM-OCD-B, DM-RD-B, DM-TM-A, DM-TS-B, DM-UTC-B

*Data Sharing BIBBS*

DS-COV-A, DS-COV-B, DS-COVU-A, DS-RP-A, DS-RP-B, DS-RPM-A, DS-RPM-B, DS-WP-A, DS-WP-B, DS-WPM-B

*Network Management BIBBS*

NM-CE-A

*Scheduling BIBBS*

SCHED-E-B, SCHED-I-B

*Trending*

T-ATR-B, T-VMT-E-B, T-VMT-I-B

- H. **Application Controller Conformance (ASC):** The ASC must be certified and listed by BTL (BACnet Testing Laboratory) under Device Profile B-ASC (Annex L of the BACnet standard) with support of the following BIBBs:

*Data Sharing BIBBS*

DS-RP-B, DS-WP-B, DS-RP-A, DS-RPM-B, DS-WP-A, DS-WPM-B, DS-COV-B, DS-COVP-B

*Device Management BIBBS*

DM-DDB-B, DM-DOB-B, DM-DCC-B, DM-DDB-A, DM-RD-B, DM-TS-B, DM-UTC-B

- I. **Read / Write Properties:** The entire BACnet BAS system (all BC, AAC and ASC devices) shall support the following Read/Write properties within the given BACnet objects and shall permit dynamic creation and deletion thereof.

*Analog Input Object*

Read and Write Properties: Description, Name, Value, COV Increment, Out of Service, Reliability

Read Only Properties: Type, Units, Status Flags, Event State

*Analog Output Object*

Read and Write Properties: Description, Name, Value, Out of Service, Reliability

Read Only Properties: Type, Units, COV Increment, Status Flags, Event State, Priority Array

*Analog Variable Object*

Read and Write Properties: Description, Name, Value, Units, COV Increment, Out of Service, Reliability

Read Only Properties: Type, Status Flags, Event State`

*Binary Input Object*

Read and Write Properties: Description, Name, Value, Out of Service, Reliability

Read Only Properties: Type, Status Flags, Event State

*Binary Output Object*

Read and Write Properties: Description, Name, Value, Out of Service, Reliability, Minimum On/Off time

Read Only Properties: Type, Status Flags, Event State, Priority Array

*Binary Variable Object*

Read and Write Properties: Description, Name, Value, Out of Service, Reliability

Read Only Properties: Type, Status Flags, Event State

*Event Enrollment Object*

Read and Write Properties: Description, Name, Notification Class, Event Enable, Event Parameter, Event Type, Object Reference

Read Only Properties: Type, Event State, Event Time Stamps, Notification Type, Acknowledged Transactions

*Notification Class Object*

Read and Write Properties: Description, Name, Priority, Recipient List

Read Only Properties: Type, Notification Class

*Calendar Object*

Read and Write Properties: Description, Name

Read Only Properties: Type, Value

*Schedule Object*

Read and Write Properties: Description, Name, Object Reference, Weekly Schedule, Effective Period, Schedule Exceptions

Read Only Properties: Type, Value

*Trendlog Object*

Read and Write Properties: None

Read Only Properties: Description, Name, Type, Notification Class, Event Enable, Event State, Event Time Stamps, Notification Type, Acknowledge Transactions, Log Enabled, Start/Stop Time, Log Interval

*Program Object*

Read and Write Properties: Description, Name, Out of Service, Reliability, Program Change

Read Only Properties: Type, Status Flags

*Loop Object*

Read and Write Properties: Description, Name, Value, COV Increment, Out of Service, Reliability, Tuning Parameters, Action, Controlled Variable

Read Only Properties: Event State, Status Flag, Type

*File Object*

Read and Write Properties: Description, Name

Read Only Properties: Type

2.01 NETWORKING COMMUNICATIONS

- A. The design of the BAS network shall integrate operator workstations and stand-alone DDC Controllers on a peer-to-peer communications network, and other devices on other networks. The network architecture shall consist of the following four levels:
1. A district-wide Ethernet communications network based on the BACnet/IP protocol (Annex J.)
  2. An auto-dial/auto-answer BACnet PTP telecommunications network.
  3. A building-wide peer-to-peer communications network between Building Controllers utilizing the BACnet protocol over Ethernet media.
  4. BACnet MS/TP secondary networks extended from appropriate Building Controllers to associated Advanced Application Controllers.
  5. Wireless communication between controllers or field devices is NOT permitted unless it has been submitted in writing for pre-approval to the OSU Project Manager.
- B. Access to system data shall not be restricted by the hardware configuration of the building automation system. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.
- C. District-wide Ethernet Communications Network (Primary Connection)
1. Local within this building, provide one Ethernet link between the campus-wide BACnet/IP network and the building-wide peer-to-peer network (Building Controller network). Only one peer-to-peer Building Controller per floor shall provide the interface to the BACnet/IP network for remote monitor, remote manual control, remote alarm, and remote programming of sequences of any and all building-wide points (BBMD device).
  2. Remote at the FOD Automation Shop (Room 208), provide one Ethernet link for monitor, control, alarm, displaying graphics, and simultaneous programming of sequences. If programming of sequences cannot be accomplished simultaneously while performing monitor, control, alarm, and displaying graphics, then provide a second Ethernet link to allow for simultaneous programming.
  3. All Ethernet communications shall include software management and control for both access and privilege. FOD Building Automation shall manage all rights for access and privilege per each remote location, for remote monitor, remote manual control, remote alarm, and remote programming of sequences of any and all building-wide points.
- D. Auto-dial/Auto-answer Telecommunication Network (Secondary connection):
1. BACnet PTP communications shall be provided to allow Building Controllers to communicate with remote operator stations and/or remote terminals on an intermittent basis via telephone lines, as indicated in the sequence of operations.
  2. Auto-dial Building Controllers shall automatically place calls to workstations to report alarms or other significant events.

- a. Building Controllers shall be able to store a minimum of 20 phone numbers of at least 20 digits. Retry a single primary number at a fixed interval until successful.
  - b. The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers. Provide as a minimum 3 secondary numbers when communications cannot be established with the primary device.
1. Operators at dial-up workstations shall be able to perform all control functions; all report functions and all database generation and modification functions as described for workstations connected via the network. Routines shall be provided to automatically answer calls from remote Building Controllers. The fact that communications are taking place with remote Building Controllers over telephone lines shall be completely transparent to an operator.
    - a. An operator shall be able to access remote buildings by selection of any facility by its logical name. The workstation dial-up program shall store the phone numbers of each remote site, so the user shall not be required to remember or manually dial telephone numbers.
    - b. A PC workstation may serve as an operator device on a network, as well as a dial-up workstation for multiple auto-dial DDC Controllers or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with network activity, nor shall network activity keep the workstation from handling incoming calls.
  2. Dial-up communications shall make use of Hayes compatible modems and voice-grade telephone lines. Provide modems rated at 56K baud with auto ranging. System access to be provided through phone lines to the existing campus Front End Computer. If applicable, the cost of the phone line installation is the responsibility of this contractor and should be included in this contract.

E. Building-wide Peer-to-Peer Communications Network:

1. Operator workstations and Building Controllers shall directly reside on an Ethernet network such that communications may be executed directly between Building Controllers and workstations on a peer-to-peer basis, without requirement for any device to operate or manage the network. A portion of the network management is built into each of the 'peer-to-peer members. 'Peer-to-peer' refers to controllers that (when interconnected) will act independently as equals, without a network manager, and will communicate in a token passing protocol with each other to pass data packet information for the purpose of building-wide monitoring and control. A special data packet called the 'token' is constantly and continually 'passed' to every member of the peer-to-peer communications network. Any peer-to-peer device on the network can send a packet of data only when it has the 'token'. Any peer-to-peer device on this network can request data from, or send data to, any other device on the network. With this procedure, token ensures that data collisions do not occur, and assures that all members of the network get equal opportunity for all data on the network.
2. Systems that operate via polled response or other types of protocols that rely on a network manager, file server, or similar device to manage panel-to-panel communications will not be considered.
3. All operator devices either resident on the peer-to-peer network, or connected via dial-up modems shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access

to the peer-to-peer network data.

4. Network design shall include the following provisions:
  - a. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. System performance shall ensure that an alarm occurring at any DDC Controller is displayed at workstations and/or alarm printers within 5 seconds.
  - b. Support of any combination of DDC Controllers and operator workstations directly connected to the peer-to-peer network. A minimum of 50 devices shall be supported on a single network (including MS/TP).
  - c. Message and alarm buffering to prevent information from being lost.
  - d. Error detection, correction and retransmission shall be included to guarantee data integrity.
  - e. Synchronization of real-time clocks, to include automatic daylight savings time updating between all controllers shall be provided. Universal Time Coordinate based upon Greenwich Mean Time must be supported. (All BC devices must have Real Time Clocks with battery and SRAM backup, see section 1.03 H)
5. Acceptable protocols for intercommunications between building-wide peer-to-peer Building Controllers:
  - a. BACnet over Ethernet (BACnet/IP between subnets only)

F. Local Area (communications) Network (LAN):

1. This communications network shall be limited to Building Controllers and Advanced Application Controllers and shall communicate bi-directionally with the BACnet peer-to-peer network.
2. Advanced Application Controllers shall be arranged on the LAN's in a functional relationship to the corresponding Building Controllers. For example, a VAV Advanced Application Controller serving a VAV terminal box shall be connected on a MS/TP network from the Building Controller that is controlling the corresponding air handling unit.
3. A maximum of 64 Advanced Application Controllers may be configured on any individual LAN from any Building Controller to insure adequate global data and alarm response times.
4. Acceptable protocols for intercommunications between Advanced Application Controllers and Building Controllers are as follows:
  - a. BACnet (MS/TP), BACnet over Ethernet

2.02 BUILDING CONTROLLER

- A. DDC (stand-alone) Controllers shall have a 32 bit processor with EEPROM, flash driven operating system (OS). They shall also be multi-tasking, multi-user, real-time digital control processors and permit I/O expansion for control / monitoring of up to 48 I/O. Controller size shall be sufficient to fully meet the requirements of this specification.

B. Each Building Controller shall have sufficient flash memory (EEPROM), a minimum of 2 megabyte, to support its own operating system. In addition, there shall be additional SRAM memory for database handling: Both the EEPROM and SRAM shall permit full implementation and support of all B-BC requirements of this specification, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
4. Historical/trend data for points specified
5. Maintenance support applications
6. Custom processes
7. Operator I/O
8. Dial-up communications
9. Manual override monitoring

C. Each Building Controller shall support:

1. Monitoring of the following types of inputs, without the addition of equipment outside of the Building Controller cabinet:
  - a. Analog inputs
    - 1) 4-20 mA
    - 2) 0-10 Vdc
    - 3) Thermistors
  - b. Digital inputs
    - 1) Dry contact closure
    - 2) Pulse Accumulator
    - 3) Voltage Sensing
2. Each Building Controller shall be capable of providing the following control outputs without the addition of equipment outside the Building Controller cabinet:
  - a. Digital outputs (contact closure)
    - 1) Contact closure (motor starters, up to size 4)
  - b. Analog outputs
    - 1) 4-20 mA
    - 2) 0-10 Vdc
    - 3) 0-135 Ohm (with external Transducer)

D. Each Building Controller shall have a minimum of 10 percent spare (panel real estate) capacity for future point connection and shall support up to 48 I/O with modular expansion modules. All expansion modules shall be located in the building controller enclosure or an attached enclosure within line of sight of the controlled equipment. The type of spares shall be in the same proportion



as the implemented I/O functions of the panel, but in no case shall there be less than two spares of each implemented I/O type. Provide all processors, power supplies, database memory, program sequence memory, and communication controllers complete so that the implementation of any added point (within the above 10% spare) only requires the addition of the appropriate point input/output termination module, point sensor, and wiring.

1. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.
  2. Building Controllers shall provide at least one RS-232C serial data communication ports (BACnet PTP compatible) for operation of operator I/O devices such as industry standard printers, operator terminals, modems and laptop portable operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals. System-wide access must be provided at each mechanical equipment room through the local Building Controller. Panel mounted terminals are not required. Furthermore, all Building Controllers shall include a hardwired, concealed and secured, RJ-11 or RJ-45 jack for use by the Portable Operators Workstation. The local operator, using the Portable Operators Workstation, shall plug into this jack, and shall perform all monitoring, control, and programming of sequences for any and all building-wide points and sequences while standing at any Advanced Application Controller.
- E. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the Building Controller via local, point discrete, hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points. These override switches shall be operable whether the panel processor is operational or not.
1. Switches shall be mounted either within the Building Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.
  2. Building Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. Building Controllers shall also collect override activity information for reports.
- G. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LED's or analog indication of value shall also be provided for each analog output.
- H. Each Building Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures and for repeated failure to establish network communications.
- I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point termination's to suppress induced voltage transients consistent with current IEEE Standard C62.41.
- J. In the event of the loss of normal power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Programs residing in memory shall be protected either by using EEPROM under capacitor backup or by an uninterruptible power source (battery backup). The backup power source shall have sufficient capacity to maintain volatile memory in event of an AC power failure. Where interruptible power source is rechargeable (a rechargeable battery), provide sufficient capacity for a minimum of seventy-two hours backup. Charging circuitry, while the controller is operating under normal line power, shall constantly charge the rechargeable power source. A non-rechargeable power source shall not be permitted. Batteries shall be implemented to allow replacement without soldering.

1. Upon restoration of normal power, the Building Controller shall automatically resume full operation without manual intervention.
  2. Should Building Controller memory be lost for any reason, the user shall have the capability of reloading the Building Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
- K. Building Controllers must comply with Section 2.02, A-J and 2.03. Panels that lose communication or control due to a single sensor failure are not permitted.
- L. Building Controllers will be used in each equipment room where major or more than two pieces of equipment are being controlled. The use of AAC or ASC devices for critical or main system equipment will not be permitted.
- M. All points associated with a given mechanical system (i.e., an air handling unit) will be controlled from a single Building Controller or point expansion panels from the respective master. (i.e., remote motor control centers). All expansion modules shall be located in the building controller enclosure or an attached enclosure within line of sight of the controlled equipment. No points from a given mechanical system may be distributed among multiple panels - points must be run back to a single Building Controller dedicated to that mechanical system. Closed-loop control must never depend upon network communications. All inputs, program sequences, and outputs for any single DDC control loop shall reside in the same Building Controller.

## 2.03 BUILDING CONTROLLER RESIDENT SOFTWARE FEATURES

- A. General:
1. All necessary software to form a complete operating system as described in this specification shall be provided.
  2. The software programs specified in this Section shall be provided as an integral part of Building Controllers and shall not be dependent upon any higher level computer for execution.
  3. Point naming convention shall be as referenced in Appendix A (see end of section). If the Appendix A does not cover the name required please submit name for approval by OSU Project Manager.
- B. Control Software Description:
1. The Building Controllers shall have the ability to perform any or all of the following pre-tested control algorithms:
    - a. Two-position control
    - b. Proportional control
    - c. Proportional plus integral control
    - d. Proportional, integral, plus derivative control
  2. Control software shall include a provision for limiting the number of times that each piece of equipment may be cycled within any one-hour period.

3. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. This feature shall be resident in all Binary Output objects. The use of custom programming to prevent an excessive demand on start-up shall not be required.
  4. Upon the resumption of normal power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.
- C. All programs shall be executed automatically without the need for operator intervention and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Sequence of Operations. Building Controllers shall have the ability to perform any or all of the following energy management routines:
1. Time-of-day scheduling
  2. 365 day Calendar-based scheduling
  3. Holiday scheduling
  4. Temporary schedule overrides
  5. Start-Stop Time Optimization
  6. Automatic Daylight Savings Time Switch over
  7. Night setback control
  8. Enthalpy switch over (economizer)
  9. Peak demand limiting
  10. Temperature-compensated duty cycling
  11. Fan speed/ control
  12. Heating/cooling interlock
  13. Cold deck reset
  14. Hot deck reset
  15. Hot water reset
  16. Chilled water reset
  17. Condenser water reset
  18. Chiller sequencing
  19. Chiller load monitoring
- D. Building Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
1. It shall be possible to use any of the following in a custom process:
    - a. Any system measured point data or status

- b. Any calculated data
  - c. Any results from other processes
  - d. User-defined constants
  - e. Arithmetic functions (+, -, \*, /, square root, exponential, etc.)
  - f. Boolean logic operators (and/or, exclusive or, etc.)
  - g. On-delay/off-delay/one-shot timers
2. Custom processes may be triggered based on any combination of the following:
    - h. Time interval
    - i. Time-of-day
    - j. Date
    - k. Other processes
    - l. Time programming
    - m. Events (e.g., point alarms)
  3. A single process shall be able to incorporate measured or calculated data from any and all other controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other controllers on the network.
  4. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
  5. The custom control programming feature shall be compiled and documented via English language descriptors. These descriptors (comment lines) shall be viewable from local operator I/O devices to facilitate troubleshooting.
- E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Building Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator activity at a PC workstation, local I/O device or communications with other panels on the network.
1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
  2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each Building Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
  3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
    - a. Each Building Controller shall be capable of storing all custom alarm text for each alarm. The alarm text shall be unique and user defined; custom text shall be available for all BACnet alarms and shall reside in the BC, not in an OWS or PC.
    - b. Alarms shall have ability to be acknowledged from the local operator I/O device, (once the problem is resolved).
  5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.
- F. A variety of historical data collection utilities shall be provided for manual or automatic sampling, storing and displaying system data for points as specified in the I/O summary.
1. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
    - a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controller. Two methods of collection shall be allowed; either by a pre-defined time interval, or upon a pre-defined change of value. Sample intervals of 1 second to 7 days shall be provided. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
  2. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either; user-defined interval, manual command, or automatically when the trend buffers are full. Furthermore, the workstation shall notify the end-user if the hard drive capacity is low or if the database size is excessive. The OWS shall use a standard MSDE or SQL database handler for all trend log management. All trend data shall be available to all BACnet OWSs and for use in 3rd party personal computer applications. File format type to be comma delineated.
  3. Building Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary. Provide capability to view or print trend and tuning reports.
    - a. The Loop object shall display the most recent historical data of its own performance. It shall illustrate the number of setpoint crossings and the maximum and average deviation from setpoint.
    - b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
- G. Building Controllers shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary.
1. The totalization routine shall have a sampling resolution of one minute or less.
  2. The user shall have the ability to define a warning limit for run-time totalization. Unique, user-specified messages shall be generated when the limit is reached.

- H. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/O summary.
  - 1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g., kWh, gallons, BTU, tons, etc.).
  - 2. The totalization routine shall have a sampling resolution of one minute or less.
  - 3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
  
- I. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for points as specified in the point I/O summary.
  - 1. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.
  - 2. The user shall have the ability to define a warning limit. Unique, user-specified messages, up to 200 characters, shall be generated when the limit is reached.
  
- J. Advanced Application Controllers:
  - 1. Each Building Controller shall be able to extend its performance and capacity through the use of remote Advanced Application Controllers. Each Advanced Application Controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Advanced Application Controller shall be a microprocessor-based, 32 bit, multi-tasking, real-time digital control processor. Provide for control of terminal equipment including, but not limited to, the following:
    - a. Rooftop units
    - b. VAV Boxes
    - c. Heatpumps
    - d. Fancoils, Univents
    - e. Other terminal equipment or monitoring
  - 2. Advanced Application Controllers must comply with Section 2.03, items A through I, and must be peer-to-peer devices. Advanced Application Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden. Switches will only be required for non-terminal applications or where controllers are readily accessible (not required for VAVs, Heatpumps, etc. that are above ceilings or inaccessible). All inputs and outputs shall be of the Universal type, allowing for additional system flexibility. A minimum of 12 global points (i.e. chilled water temperature, hot water temperature, etc.) must be able to be accessed through the Advanced Application Controller. If global point access is unavailable with the Advanced Application then a Building Controller must be furnished.
  - 3. Each Advanced Application Controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event

that communication with its Building Controller is lost and to insure protection during power outages. In the event that the AAC does not support a real time clock (RTC) function and it is being used on critical or system level equipment as mentioned in section 2.03 J.1 then a Building Controller supporting RTC functionality shall be used in its place. AAC devices without RTC functionality will be permitted for use on terminal or unitary equipment such as VAV boxes, fancoils, heatpumps, univents and auxiliary monitoring and control.

4. Provide each Advanced Application Controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM under capacitor backup (lithium or rechargeable battery backup will not be permitted). Advanced Application Controllers must be fully programmable with a minimum of 200 lines of code available for custom programming. All programs shall be field-customized to meet the user's exact control strategy requirements. Advanced Application Controllers utilizing pre-packaged or canned programs shall not be acceptable. As an alternative, provide Building Controllers for all central equipment in order to meet custom control strategy requirements.
5. Programming of Advanced Application Controllers shall utilize the same language and code as used by Building Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide a Building Controller to meet the specified functionality.
6. Local alarming and trending capabilities shall be provided for convenient troubleshooting and system diagnostics. Alarm limits and trend data information shall be user-definable for any point.
7. Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs. All new values and programs may then be restored to EEPROM via the programming tool.
8. Advanced Application Controllers that lose communication with master panels, and/or lose control due to a single sensor failure, are not acceptable.
9. At all Advanced Application Controllers include a hardwired, concealed and secured, RJ-11 or RJ-45 jack for use by the Portable Operators Workstation. The local operator, using the Portable Operators Workstation, shall plug into this jack, and shall perform all monitoring, control, and programming of sequences for any and all building-wide points and sequences while standing at any Advanced Application Controller.
10. At all Advanced Application Controllers, include the point database of the following minimum building-wide system data:
  - i. Building Primary Hot Water Return and Supply Temperatures
  - j. Building Primary Chilled Water Return and Supply Temperatures
  - k. Building Common Outside Air Temperature
  - l. Database for 10 other building-wide points, as field selected by OSU.
  - m. All VAV boxes including but not limited to dual duct boxes, mixing boxes, fan powered shall include a discharge air sensor.

#### 2.04 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. AAC devices shall be used for all intended ASC functionality. Use of Application Specific Controllers in lieu of Advanced Application Controllers requires prior approval by the University Engineer.
- B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, 32-bit, multi-tasking, real-time digital control processor.
- C. The use of these ASCs is limited to the monitor and control of building HVAC equipment that are outside of any mechanical equipment room, or outside of any electrical equipment room. All equipment located within, or controlled from within, any mechanical equipment room or electrical equipment room shall use the peer-to-peer Building Controller.
- D. The electrical power source for these Application Specific Controllers shall be from local circuit breaker with appropriate fused, class 2, 100VA power-limited output. The breaker shall be dedicated to the Advanced Application Controllers, labeled accordingly, and locked-out from inadvertent casual shutoff.
- E. Application Specific Controllers:
  1. Provide for control of each piece of building HVAC equipment, including, but not limited to, the following:
    - a. Variable Air Volume (VAV) terminal boxes
    - b. Constant Air Volume (CAV) terminal boxes
    - c. Dual Duct (DD) terminal boxes
    - d. Unit Conditioners
    - e. Heat Pumps
    - f. Unit Ventilators
    - g. Fan Coil Units
  2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. All inputs and outputs shall be of the universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. Analog outputs shall be industry standard signals such as 24V floating control and 0-10 VDC allowing for interface to a variety of modulating actuators. Terminal equipment controllers or AACs utilizing proprietary control signals and actuators shall not be acceptable. As an alternative, provide Building Controllers or other AACs with industry standard outputs for control of all terminal equipment.
  3. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor shall be 10K Type-3 thermistor based providing the following minimum performance requirements are met:
    - a. Accuracy:  $\pm 0.36^{\circ}\text{F}$
    - b. Operating Range:  $32^{\circ}$  to  $158^{\circ}\text{F}$
    - c. Set Point Adjustment Range:  $55^{\circ}$  to  $85^{\circ}\text{F}$  (adjustable)
    - d. Set Point Modes:



- 1). Independent Heating
    - 2). Independent Cooling
    - 3). Night Setback Heating
    - 4). Night Setback Cooling
  - e. Calibration Adjustments: None required
  - f. Installation: Up to 500 ft. from Controller
  - g. Each room sensor shall also include the following auxiliary devices or options:
    - 1). Setpoint Adjustment Dial or equivalent buttons
    - 2). Digital LED Temperature Indicator
    - 3). Override Switch or button
    - 4.). 2 % on board Humidity Sensor option
  - h. The setpoint adjustment shall allow for modification of the temperature in a minimum of .5° F increments by the occupant. Setpoint adjustment may be locked out, overridden or limited as to time or temperature through software by an authorized operator at the central workstation, Building Controller, or via the portable operator's terminal.
  - i. The temperature indication shall be a digital display visible without removing the sensor cover.
  - j. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, Building Controller, or via the portable operator's terminal.
4. Each controller shall perform its primary control function independent of other DDC Controller LAN communications, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the Building Controller time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) values for all applications. All PID values and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings. Controllers that incorporate proportional and integral (PI) control algorithms only, without derivative (D) control algorithms, shall not be acceptable.
5. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or capacitor backup. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPS's) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be fully customizable for specific applications (programming language shall be identical to the Building Controllers). In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of any applications or that are algorithm based will not be acceptable.
6. Variable Air Volume (VAV) Box Controllers:
- a. As a minimum, shall support the following types of applications for pressure independent terminal control:

- 1). VAV, cooling only
  - 2). VAV, with hot water reheat
  - 3). VAV, with electric reheat
  - 4). VAV, fan-powered
  - 5). VAV, fan-powered, with hot water reheat
  - 6). VAV, fan-powered, with electric reheat
- b. All VAV box control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory changes of any applications or that are algorithm based will not be acceptable
7. The VAV box controller shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 130°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
- a. The VAV controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 1 inch-WC and measurement accuracy of  $\pm 5\%$  throughout its range, insuring primary air flow conditions shall be controlled and maintained to within  $\pm 5\%$  of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.
  - b. The VAV box controller shall include provisions for manual and automatic reset of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Reset shall be accomplished by stroking the terminal unit damper actuator to 0%, full closed, position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the end user desires. Manual reset may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Reset of the transducer at the controller location shall not be necessary.
  - c. The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^\circ\text{F}$  (adj.) of setpoint at the room sensor location.
  - d. The VAV box controller performing space heating control shall incorporate a program allowing for modulation of a hot water reheat valve, or cycling up to three (3) stages of electric reheat, as required to satisfy space heating requirements. Each controller shall also incorporate a program that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.

- e. All VAV boxes including but not limited to dual duct boxes, mixing boxes, fan powered shall include a discharge air sensor.
8. Constant Air Volume (CAV) Box Controllers:
- a. As a minimum, shall support the following types of applications for pressure independent terminal control:
    - 1). CAV, cooling only
    - 2). CAV, with hot water reheat
    - 3). CAV, with electric reheat
  - b. All CAV box control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes or those that are algorithm based will not be acceptable.
  - c. The CAV box controller shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC, allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 130°F and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
  - d. The CAV controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 1 inch-WC and measurement accuracy of  $\pm 5\%$  throughout its range, insuring primary air flow conditions shall be controlled and maintained to within  $\pm 5\%$  of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.
  - e. The CAV box controller shall include provisions for manual and automatic reset of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Reset shall be accomplished by stroking the terminal unit damper actuator to 0%, full closed, position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the end user desires. Manual reset may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Reset of the transducer at the controller location shall not be necessary.
  - f. The CAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^\circ\text{F}$  (adjustable) of setpoint at the room sensor location.
  - g. Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve or cycling up to three (3) stages of electric reheat as required to satisfy space heating requirements. Each controller shall also incorporate a program that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space

cooling requirements. This program shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint. Control of the terminal unit damper to maintain cooling setpoint shall not be permitted. As an alternative, Building Controllers or other Advanced Application Controller for the associated air handling equipment shall also directly control all CAV terminal units in order to provide the specified reset capability

- h. Each controller performing space pressurization control shall incorporate programs allowing for pressurization via the following methods as a minimum:
    - 1). Fixed air volume setpoints of supply and exhaust terminal units
    - 2). Updating of air volume setpoints of supply and exhaust terminal units
  - i. Each supply and associated exhaust terminal controller may be set at a fixed air volume setpoint which is within a percentage of each other or an actual CFM differential to meet space pressurization requirements. The controllers shall incorporate provisions for independent occupied and unoccupied mode setpoints and differentials, allowing for additional flexibility. Applications requiring updating of air volume setpoints depending on a variable volume of air leaving the space either through the exhaust terminal(s) or other exhaust ducts shall utilize supply terminal unit controllers incorporating programs to allow for "tracking" of space exhaust(s) to maintain the required air volume differential.
  - j. Terminal unit tracking shall be accomplished via actual measurement of terminal unit air volumes as previously specified. Controllers which track within a range of CFM's versus actual CFM setpoints shall not be acceptable.
  - k. Zeroing of the differential pressure transducer shall be accomplished as previously specified for VAV box controllers. However, the method of stroking the terminal unit damper to a 0% position shall not be permitted should the controlled space(s) require constant pressurization or 24-hour per day operation. Controllers performing under 24-hour per day operation requirements shall incorporate an 'Auto-zero' auxiliary device(s) which functions to automatically zero the transducer without changing the damper position. This shall be accomplished by temporarily disengaging the transducer from the air velocity sensor so that a 0 cfm air volume reading is forced. The control damper position remains unchanged, as originally controlled before the start of the 'Auto-zero' recalibration. This shall automatically occur on a once per 24-hour basis, thus ensuring system accuracy as previously specified. Provide auxiliary devices and programming as required to perform this function.
  - l. Should a failure occur within the controller, the terminal unit damper shall automatically be positioned fully open or fully closed as previously defined by the operator. Controllers that revert to a pressure-dependent control mode during failure shall not be acceptable.
  - m. All VAV boxes including but not limited to dual duct boxes, mixing boxes, fan powered shall include a discharge air sensor.
9. Dual-Duct (DD) Box Controllers:
- a. As a minimum, shall support the following types of applications for pressure independent terminal control:
    - 1). DD - Constant Volume - Cold Duct & Hot Duct Air Velocity Sensors with optional auxiliary heat.

- 2). DD - Constant Volume - Cold Duct & Outlet Air Velocity Sensors with optional auxiliary heat.
  - 3). DD - Variable Air Volume - Cold Duct & Hot Duct Air Velocity Sensors with optional auxiliary heat.
  - 4). DD - Variable Air Volume - Cold Duct & Outlet Air Velocity Sensors with optional auxiliary heat.
  - 5). DD -Variable Air Volume - Cold Duct & Hot Duct Air Velocity Sensors with changeover.
- b. All DD box control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes or those that are algorithm based will not be acceptable.
  - c. The DD box controller shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 130°F and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
  - d. The DD controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 1 inch-WC and measurement accuracy of  $\pm 5\%$  throughout its range, insuring primary air flow conditions shall be controlled and maintained to within  $\pm 5\%$  of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.
  - e. The DD box controller shall include provisions for manual and automatic reset of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Reset shall be accomplished by stroking the terminal unit damper actuator to 0%, full closed, position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the end user desires. Manual reset may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Reset of the transducer at the controller location shall not be necessary.
  - f. The DD box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^\circ\text{F}$  (adjustable) of setpoint at the room sensor location.
  - g. Each controller performing space heating control shall incorporate a program allowing for modulation of a hot water reheat valve or cycling up to two (2) stages of electric reheat as required to satisfy space heating requirements.
  - h. Provide two air velocity sensors and transducers to match the application. For VAV applications, provide separate minimum and maximum air volume setting for heating and cooling ducts. For CAV applications, provide separate air volume set points for occupied and unoccupied modes.

- i. Zeroing of the differential pressure transducer shall be accomplished as previously specified for VAV box controllers. However, the method of stroking the terminal unit damper to a 0% position shall not be permitted should the controlled space(s) require constant pressurization or 24-hour per day operation. Controllers performing under 24-hour per day operation requirements shall incorporate an 'Auto-zero' auxiliary device(s) which function to automatically zero the transducer without changing the damper position. This shall be accomplished by temporarily disengaging the transducer from the air velocity sensor so that a 0 cfm air volume reading is forced. The control damper position remains unchanged, as originally controlled before the start of the 'Auto-zero' recalibration. This shall automatically occur on a once per 24-hour basis, thus ensuring system accuracy as previously specified. Provide auxiliary devices and programming as required to perform this function.
  - j. All VAV boxes including but not limited to dual duct boxes, mixing boxes, fan powered shall include a discharge air sensor.
10. Unit Conditioner Controllers:
- a. As a minimum, shall support the following types of applications for terminal control:
    - 1). Fan coil units
    - 2). Induction units
    - 3). Pressure dependent terminal boxes
  - b. As a minimum, shall support the following types of fan coil units:
    - 1). Fan Coil, 2-pipe, heating or cooling
    - 2). Fan Coil, 4-pipe, heating or cooling
    - 3). Fan Coil, cooling, and electric heating
    - 4). Fan Coil, 2-stage cooling, and electric heating
    - 5). Fan Coil, 2-stage cooling, and hot water heating
  - c. As a minimum, shall support the following types of Induction units:
    - 1). Induction Unit, 2-pipe
    - 2). Induction Unit, 4-pipe
  - d. As a minimum, shall support the following types of pressure dependent terminal control:
    - 1). Heating, or cooling
    - 2). Hot water reheat
  - e. All Unit Conditioner control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes or those that are algorithm based will not be acceptable.
  - f. The Unit Conditioner controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC, allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 130°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable

cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).

- g. The Unit Conditioner controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^{\circ}\text{F}$  (adjustable) of setpoint at the room sensor location.
  - h. The Unit Conditioner controller performing space temperature control shall incorporate a program allowing for modulation of a hot water reheat and chilled water valve, or cycling up to three (3) stages of electric reheat and chilled water valve, as required to satisfy space heating requirements. Each controller shall also incorporate a program that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements (if applicable). This program shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.
  - i. All VAV boxes including but not limited to dual duct boxes, mixing boxes, fan powered shall include a discharge air sensor.
11. Heat Pump Controllers:
- a. As a minimum, shall support the following types of applications for heat pump terminal control:
    - 1). Heat Pump, water source
    - 2). Heat Pump, air-to-air source
    - 3). Heat Pumps, with ventilation air
    - 4). Heat Pump, with auxiliary heat
  - b. All Heat Pump control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes or those that are algorithm based will not be acceptable.
  - c. The Heat Pump controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC, allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of  $32^{\circ}$  to  $130^{\circ}\text{F}$  ( $0^{\circ}$  to  $50^{\circ}\text{C}$ ) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
  - d. The Heat Pump controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^{\circ}\text{F}$  (adjustable) of setpoint at the room sensor location.
  - e. The Heat Pump controller performing space temperature control shall permit full control of the Heatpump regardless of its configuration.
  - f. All VAV boxes including but not limited to dual duct boxes, mixing boxes, fan powered shall include a discharge air sensor.

12. Unit Ventilator Controllers:

- a. As a minimum, shall support the following types of applications for heating only unit ventilator applications:
  - 1). Unit Ventilator, ASHRAE Cycle 1, 2 or 3
  - 2). Unit Ventilator, ASHRAE Cycle 1, 2 or 3 with auxiliary reheat
  - 3). Unit Ventilator, Nesbitt Cycle W
  - 4). Unit Ventilator, Nesbitt Cycle W with auxiliary reheat
- b. All Unit Ventilator controller applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes or those that are algorithm based will not be acceptable.
- c. The Unit Ventilator controllers shall be powered from either a 115 or 230 VAC power source common to the unit ventilator. The controllers shall function normally under ambient conditions of 32° to 130°F and 10% to 95% (non-condensed). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
- d. The Unit Ventilator controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^{\circ}\text{F}$  (adjustable) of setpoint at the room sensor location.
- e. The Unit Ventilator controller shall also interface to averaging temperature sensor(s) located in the discharge or mixed air stream(s) as required by application. The sensor(s) must be 10-K type 3 thermistors, providing the following minimum performance requirements are met:
  - 1). Probe: Averaging type
  - 2). Accuracy:  $\pm .50^{\circ}\text{F}$
  - 3). Temperature Monitoring  $0^{\circ}$  to  $180^{\circ}\text{F}$  ( $-18^{\circ}$  to  $82^{\circ}\text{C}$ )

## 2.05 PORTABLE OPERATOR'S TERMINAL (POT)

- A. Provide One (1) portable operator terminal (POT). The POT shall be a laptop configuration and plug directly into any control panel. Provide the BACnet BAS software as required to provide complete functionality for viewing, modifying, restoring, and archiving of all data (including custom programs). The software used to setup and configure the BAS controls shall be the same software provided to the University at no additional expense.
- B. Functionality of the portable operator's terminal connected at any controller:
  - 1. Access all controllers on the network.
  - 2. Backup and/or restore DDC Controller databases for all system panels, not just the DDC Controller connected thereto.
  - 3. Display all point, selected point and alarm point summaries.
  - 4. Display trending and totalization information.
  - 5. Add, modify and/or delete any existing or new system point.
  - 6. Command, change setpoint, enable/disable any system point.



7. Program and load custom control sequences as well as standard energy management programs.
- C. Connection of a POT to a distributed control processor shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.
- D. Portable operator terminal access to controller shall be password-controlled.
- E. Portable operator terminal minimum hardware and performance criteria shall be as referenced in Appendix A.1.

## 2.06 WORKSTATION OPERATOR INTERFACE SOFTWARE

### A. Basic Interface Description

1. Operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification and industry standard PC application software. The software shall provide, as a minimum, the following functionality:
  - a. Graphical viewing and control of environment
  - b. Scheduling and override of building operations
  - c.
  - d. Definition and construction of dynamic and animated color graphic displays
  - e. Editing, programming, storage and downloading of controller databases
2. Provide a graphical user interface, which shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.
  - a. Provide functionality such that all operations can also be performed using the keyboard as a backup interface device.
  - b. Provide additional capability that allows at least 10 special function keys to perform often-used operations.
3. The software shall provide multi-tasking operating system such that alarm notification occurs while user is running other applications such as Word or Excel; trend data uploads occur in the background while other applications are running. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows<sup>a</sup> or similar industry standard software that supports concurrent viewing and controlling of systems operations.
  - a. Provide functionality such that any of the following may be performed simultaneously, and in any combination, via user-sized windows: (Vector based graphics)
    - 1). Dynamic and animated color graphics and graphic control
    - 2). Alarm management coordinated with section 2.04.E.
    - 3). Time-of-day scheduling
    - 4). Trend data definition and presentation
    - 5). Graphic definition
    - 6). Graphic construction

- b. If the software is unable to display several different types of displays at the same time, the BAS contractor shall provide at least two operator workstations.
4. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities. Privileges shall be customizable for each operator; the main menu shall reflect the privileges upon log on showing only the applications appropriate for the operator.
  - a. Customizable such that operators can monitor, command, or edit an application or group of points. An operator can be defined with privileges for access to a building, group or buildings, or areas (labs--point names with the designation "lab"), by application: the operator has monitor, command, and edit capability for time of day schedules and calendars (only) for the entire campus: or by function: the operator (i.e. security guard) has ability to view/monitor all areas of the campus and receive alarms, etc.
  - b. A minimum of 50 unique passwords, including user initials, shall be supported.
  - c. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used to log-on.
  - d. The system shall automatically generate a report of log-on/log-off time and system activity for each user.
  - e. User-definable, automatic log-off timers of from 5 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line as well as have the capability to generate a report of log-on, log-off time, parameters modified, and system activity for each user.
5. Software shall allow the operator to perform commands including, but not limited to, the following:
  - a. Start-up or shutdown selected equipment
  - b. Adjust setpoints
  - c. Add/modify/delete time programming
  - d. Enable/disable process execution
  - e. Lock/unlock alarm reporting for points
  - f. Enable/disable totalization for points
  - g. Enable/disable trending for points
  - h. Override PID loop setpoints
  - i. Enter temporary override schedules
  - j. Define holiday schedules
  - k. Change time/date
  - l. Automatic daylight savings time adjustments
  - m. Enter/modify analog alarm limits
  - n. Enter/modify analog warning limits

- o. View limits
- p. Enable/disable demand limiting for each meter
- q. Enable/disable duty cycle for each load
- r. Operator shall have ability to schedule reports to print at a pre-specified time and frequency and directed to displays, printers, disk or emails. The reports shall be capable of querying all BACnet devices for all BACnet data and shall be available in industry standard formats such as Acrobat, Microsoft Word, Microsoft Excel and Crystal Reports.

1) Summaries shall be provided for specific points, for a logical point group, for a user-selected group or groups or for the entire BACnet network without restriction due to the hardware configuration of the building automation system. At a minimum, the report function shall provide all required BACnet data for the previously identified BACnet objects in section 2.00 J.

B. Scheduling

- 1. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum:
  - a. BACnet schedules
  - b. BACnet calendars
- 2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupancy and vacancy times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
- 3. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commandable points residing within the zone, unless custom programming is used to enable/disable the points. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone.
- 4. Monthly calendars, until the year 2020, shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

C. Collection and Analysis of Historical Data

- 1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. In addition, the BAS system shall automatically trend and archive all alarms and user activity (no exceptions).
- 2. Trend data report graphics shall be provided to allow the user to view all trended point data. The BAS system shall employ the use of Multiple Trend-Logs which may be

customized to include up to 8 individual single trends in one viewable and printable format. Provide additional functionality to allow any trended data to be transferred easily to Microsoft Office, Excel®. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.

3. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A maximum of 8 points may be viewed simultaneously on a single graph, with color selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.
  - a. Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.
  - b. Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

D. Dynamic Color Graphic Displays

1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, room level terminal unit equipment shall be provided by the BAS contractor as indicated in the point I/O summary of this specification to optimize system performance analysis and speed alarm recognition. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.
2. Dynamic temperature values, humidity values, flow values, percent load, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.
3. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
4. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays.
  - a. The BAS contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.

- b. The graphic package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:
  - 1) Define symbols
  - 2) Position and size symbols
  - 3) Define background screens
  - 4) Define connecting lines and curves
  - 5) Locate, orient and size descriptive text
  - 6) Define and display colors for all elements
  - 7) Establish correlation between symbols or text and associated system points or other displays
  - 8) Ability to import scanned images and CAD drawings in Autodesk ®, DWG format.
- c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points that aids the operator in the analysis of the facility.
  - 1) To accomplish this, the user shall be able to build graphic displays that include point data from multiple controllers.
- 5. Dynamic system status graphic of the site-specific architecture showing status of system hardware, including quantity and address of networks, field panels, terminal equipment controllers, and printers.
- 6. The BAS contractor shall employ the use of accurate floor plans as part of the overall graphics package. The floor plans shall illustrate the location of room sensors and equipment. In addition, the floor plans shall utilize a thermographic scheme to instantly alert the end user of hot and cold areas. The thermograph shall illustrate and automatically intensify the red and blue gradient fills for each area, as to indicate the severity of the overheating or overcooling problem.

E. System Configuration and Definition:

- 1. All temperature and equipment control strategies and energy management routines shall be definable and fully programmable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
- 2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
  - a. Add/delete/modify stand-alone Building Controllers
  - b. Add/delete/modify stand-alone Advanced Application Controllers
  - c. Add/delete/modify operator workstations
  - d. Add/delete/modify Application Specific Controllers, if used
  - e. Add/delete/modify points of any type and all associated point parameters and tuning constants
  - f. Add/delete/modify alarm reporting definition for points
  - g. Add/delete/modify control loops
  - h. Add/delete/modify energy management applications

- i. Add/delete/modify time and calendar-based programming
  - j. Add/delete/modify totalization for points
  - k. Add/delete/modify historical data trending for points
  - l. Add/delete/modify custom control processes
  - m. Add/delete/modify any and all graphic displays, symbols and cross-reference to point data
  - n. Add/delete/modify dial-up telecommunication definition
  - o. Add/delete/modify all operator passwords
  - p. Add/delete/modify alarm messages
3. Definition of operator device characteristics, any controller's individual points, applications and control sequences shall be performed using instructive prompting software.
- a. All custom programming language must be line sequential, English text with a real time compiler. The operator shall be able to view all live data within the program with no exceptions. The use of secondary software or manual intervention shall not be required.
  - b. If programming must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.
  - c. Inputs and outputs for any process shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).
  - d. Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate controller. Similarly, changes made at any Controllers shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.
  - e. Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed. The help menus shall be readily accessible by selecting an icon or by pressing a function button on the keyboard.

## 2.07 FIELD DEVICES

- A. Temperature Sensors: Each temperature sensor shall match the requirements of the associated temperature controller and shall be based upon 10-K Type-3 thermistors. Each sensor shall be designed for the appropriate application (i.e., duct, immersion, etc.) and be provided with all necessary installation accessories. Ranges shall be selected to the middle of the control range. Temperature sensors must have a minimum accuracy of +/- 0.5 deg F or .5 % of scale; whichever will provide the least error in measurement.

1. Electronic: A modulating solid state sensor with built-in detector, with continuous voltage or current output. Each sensor shall have individual setpoint adjustment. Input voltage shall be 24 VAC or less. Sensors shall be of matching type to the input detectors and output drives or sequencers.
  2. Thermostat guards shall be provided where specified, indicated on control diagrams, or indicated on floor plans. Guards shall be firmly attached to wall and thermostat cover shall be visible through the guard. All room sensors in public areas will have concealed setpoint adjustments.
  3. All room sensors in classroom, office, or common spaces will have exposed set point adjustments locked to provide adjustment between 68 degrees and 72 degrees only.
  4. Install thermostats and sensors at 4'-6" AFF to bottom unless otherwise noted on Architectural Drawings. Coordinate installation with the work of other trades before any rough-ins are made.
  5. Duct Sensors: DDC duct sensors shall match the requirements of the associated controller incorporating an electrical signal to insure exact and proportional relationship between the measured variable and the transmitted signal. Static pressure sensors shall be mounted in temperature control panels with connecting sensor lines in hard copper. Where a device is used for sensing of Mixed Air Temperature or Preheat applications and the duct area is in excess of 24 square feet the instrument shall incorporate a capillary averaging element with a minimum length of 96 inches or a suitable array of duct sensors wired as a single input. Averaging sensors shall be used on any duct application where duct area exceeds 24 square feet.
  6. Provide temperature sensors as required to meet the sequence of operation; in addition, provide temperature sensors in the following locations: return air, mixed air and discharge air sections if not required by the sequence of operation.
  7. Wireless sensors are NOT permitted unless it has been submitted in writing for pre-approval to the OSU Project Manager.
- B. Humidity Sensors: The relative humidity transmitter monitors and transmits changes in humidity, accurate to +/- 2 % RH. Operating range shall be 0 to 99% RH.
- C. Pressure Sensors: Duct static pressure analog sensors shall be high accuracy +/-1% of range suitable for the low pressures and selected for at least 50% over range Sensors shall have industry standard 4-20 mA output and zero end span adjustments.
- D. Control Dampers (Multiple Blade Dampers): Automatic dampers furnished by the BAS Contractor shall be single blade or multiple blades as applicable. All dampers are to be sized to the application by the manufacturer using methods similar to control valve sizing. Dampers are to be installed by the HVAC Contractor under the supervision of the Temperature Control Contractor. All dampers furnished by air handling unit manufacturers must meet the requirements listed in this section. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the HVAC Contractor. All damper frames are to be constructed of No. 13 gauge galvanized sheet metal and shall have flanges for duct mounting. Damper blades shall not exceed 6 inches width. All blades are to be airfoil type construction and will be equal to Ruskin RCD 50 control dampers with blade and jamb seals. Blades are to be suitable for high velocity performance. All damper bearings are to be made of nylon. Bushings that turn in the bearings are to be oil impregnated sintered metal. Dampers hung with blades mounted vertically shall be provided with thrust bearings. Butyl rubber seals are to be installed along the top and bottom of the frame and along each blade edge. Independent, self-compensating, stainless steel end seals shall be installed to insure minimum leakage between blade ends and damper frame. Seals shall provide a tight closing low leakage damper. Damper sections shall not exceed 48" in length or 16 sq. ft. and shall have minimum of one operator per damper section. All dampers in modulating

applications shall have opposed blades. Dampers in two position services shall have parallel blades. Where sequence requires, submittals shall include damper sizes and leakage characteristics. Leakage shall not exceed 1 % at 4" W.C. when tested per AMCA Standard 500.

1. Control dampers will be sized by the temperature control contractor to the inside of the duct or duct liner whichever is smaller. Sizing of dampers to duct size and the subsequent cutting back of insulation to make dampers fit is unacceptable.
  2. Control dampers used for outside air or exhaust air applications will be installed a minimum of 6" away from wall penetrations to allow for external mounting of their respective damper motors. Jack shafting in these applications will only be allowed to prevent having to mount motors in the outside airstream. When internal damper motor mounting is required the sheet metal contractor shall provide access panels at each motor location to allow for ease of service.
- E. Damper Operators: Operators shall be electronic, spring return, low voltage (24VAC), and shall be properly sized so as to stroke the damper smoothly and efficiently throughout its range. Actuator responses shall be linear in response to sensed load.
1. Electronic damper motors for terminal boxes will be provided by the temperature control contractor and shipped to the terminal box manufacturer for mounting. Mounting charges shall be the responsibility of the terminal box manufacturer.
  2. Damper operators on outside air intake/exhaust shall be spring return closed.
  3. VAV Terminal Boxes using internal or proprietary actuators are unacceptable.
- F. Automatic Control Valves: All valves sized greater than 2 ½" or steam applications shall be pneumatic. All valves shall be equipped with throttling plugs and removable composition discs and shall be manufactured by Siemens, Belimo, or Johnson Controls. All valves are to be sized by the Control Contractor and shall submit pressure drop calculations and guarantee sufficient size to meet the requirements of the equipment being served. Valve operators shall be of such design so as to provide adequate operating power for valve positioning.
1. Reheat valves controlled by AACs in VAV terminal applications shall utilize electronic actuation and shall fail normally closed (capacitor or spring driven failsafe). All reheat valves serving Laboratories and/or Vivariums (animal) rooms shall be electronic actuation and include spring return, to fail normally closed.
  2. Three-way Valves: Three-way valves are to be of the three port mixing arrangement, designed expressly for mixing of two inlets and providing a common outlet. The use of reverse piped diverting valves shall not be acceptable. The Temperature Control Contractor will assist the HVAC Contractor in providing guidance as to the correct method of piping of all three-way valves. It is the responsibility of the HVAC contractor to evaluate the contract drawings for proper verification.
  3. Butterfly valves for air handling unit coil control are unacceptable. If high GPM requirements dictate the valve size to be greater than 6", then Temperature Control contractor shall provide two control valves for the application, and the HVAC Contractor shall install the two control valves, for parallel and/or sequenced operation.
  4. For all fan systems with separate pre-heat and separate 2<sup>nd</sup> heating coil. The pre-heat coil shall fail normally open, shall include separate analog output AO point for control, and separate analog input AI point for low-limit pre-heat discharge control. The separate 2<sup>nd</sup> heating coil shall fail normally closed, shall include separate analog output AO point, and separate analog input AI point for low-limit heating control.
  5. For all fan systems with a single hot water coil, the coil shall fail normally open (i.e. AHUs, Fancoils Univents, UHs, CUHs, etc.)



6. Pressure drop through modulating control valves shall not exceed 7 psi and should be matched to the coil pressure drop whenever possible. Control valves for 2-position applications shall be line sized.
- G Air Volume Measurement: Provide Tek-Air or Ebtron air flow measuring system including microprocessor panel and air flow measuring sensor struts as required to measure outside air intake flow as denoted on the Drawings.
1. DDC air flow measuring system shall have a velocity range from 350 to 6000 ft./min. with duct measurement accuracy (including repeatability, zero offset, and temperature compensation) of plus or minus 0.5 percent.
  2. Pilot tube arrays and differential pressure arrays are not acceptable.
  3. The air flow measurement stations shall include a digital LCD display that illustrates the actual CFM, not FPM or other variables.
- H Smoke Detectors shall be provided and installed by the HVAC contractor. The electrical contractor will provide the necessary interlock wiring for life safety functions.
- I Air Static and Velocity Pressure Transmitter: The pressure transmitter shall be used for measuring duct static or velocity pressure in variable air volume fan systems.
- J Low Limit Detection Thermostat: Low limit detection thermostats equal to Siemens 134-1511 shall be of the vapor tension capillary type having a sensing element a minimum of 20 feet in length. These thermostats shall be of the manual reset type. The elements shall be complete with necessary fittings to permit installation in the duct so as to sense the correct discharge temperatures. One low limit detection thermostat will be installed for every 24 square feet of protected area and arranged so as to stop their respective units and close the outside air dampers in the event discharge temperatures fall below 38 degrees F. The normally closed contact shall be wired to the fan circuit and the normally open contact (close on alarm) shall be wired to a DDC input. One common circuit is suitable for multiple thermostats on a single AHU coil area.
- K Electric Thermostats: Heavy-duty snap action type with key operators rated at 10 FLA at 120 RIAC contacts suitable for the intended service. Provide manual selector switches as required in the sequence of operation.
- L Fan and Pump Proof: Proof points for air handling unit fans, exhaust fans and pumps will be accomplished through the use of current sensing relays at the motor control center or motor starters. Current sensing relays shall be split-core design, for installation over any single power lead. Current sensing relays shall include field adjustable set screw for amperage setpoint adjustment, and shall include integral LED status light to locally indicate the 'on' and 'off' condition.
- M Variable Frequency Drives: The Variable Frequency Drives (VFDs) shall be BACnet compatible. It is the responsibility of the BAS contractor to coordinate with the HVAC contractor to ensure that the proper drive is ordered with the appropriate native BACnet communications card (no gateways allowed).
- N. Electro-pneumatic (EP) transducers: "Poppet" valve style EP transducers are prohibited in occupied spaces, above the ceilings of occupied spaces, and wherever noise could be an issue. They are acceptable for mechanical room applications.

### 2.08 LABELING

- A. Provide labels for all field devices including sensors, transducers, thermostats, and relays. Exception: Room temperature and/or humidity sensors shall not be labeled.

- B. Labels shall be black laminated plastic with white letters and adhesive backing or screw fasteners. Labels shall be located adjacent to device and permanently affixed to device mounting surface. Labels for sensors in pipes may be secured using chain around the sensor well.
- C. Labels shall include system virtual/pseudo point name as well as English language name of device being controlled or specific condition being sensed.
- D. Identify all control wiring at each end with a wire tags or labels machine print (no hand written).
- E. Identify and label all control transformers by indicating all devices they power.

**PART 3 EXECUTION**

**3.01 SEQUENCE OF OPERATION**

**3.02 ON-SITE TESTING**

- A. Field Test: When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. The installer shall complete all testing, calibrating, adjusting and final field tests. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. Upon completion of the work, contact the third party commissioning agent that the system is ready for final tests and commissioning. If there is no commissioning agent, contact the OSU Project Manager, and Architect/Engineer to inform them that the system is ready for final tests and commissioning. Commissioning shall be performed on all systems in BOTH heating and cooling seasons.
- B. At the time of final inspection, this Contractor shall be represented by a person with the proper authority, who shall demonstrate, as directed by the commissioning agent or the A/E, that his work fully complies with the purpose and intent of the Specifications and Drawings. Labor, services, instruments, and tools necessary for demonstrations and tests shall be provided by the Contractor.
- C. The Contractor shall test and adjust each instrument specialty and equipment furnished by him, prior to final acceptance. The Contractor shall demonstrate, for approval by the A/E, subsystems operate as coordinated and properly functioning, integrated system including the graphics, alarms and trending.
- D. The Contractor shall furnish labor to provide adjustments and incidentals necessary to obtain the desired and intended results.
- E. The Contractor shall turn over a printed copy and electronic copy of the completed and debugged operating software to OSU Construction Manager at the conclusion of the two year warranty.

**3.03 SERVICE AND GUARANTEE**

- A. General Requirements: Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year after completion of successful commissioning. Provide necessary material required for the work. Minimize impacts on facility operations when performing scheduled adjustments and non-scheduled work.
- B. Description of Work: The adjustment and repair of the system includes all computer equipment, software updates (including all firmware updates), transmission equipment and all sensors and control devices. Provide the manufacturer's required adjustments and all other work necessary.

- C. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. University shall be advised in writing of the name of the designated service representative, and of any changes in personnel.
- D. Systems Modifications: Provide any recommendations for system modification in writing to University. Do not make any system modifications, including operating parameters and control settings, without prior approval of the OSU Project Manager. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.
- E. Software: Provide all software updates and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with the OSU Project Manager, and shall be incorporated into the operations and maintenance manuals, and software documentation.
- F. As-Builds: Submit 1 complete sets of drawings to the OSU Project Manager bound in a three ring binder showing the kind of control equipment for each of the various systems and their functions, along with indications on the drawing of all original setpoints and calibration values, and setup parameters, and sequence of operation of the automation system together with a complete brochure describing the equipment and their functions and operation. Include all application software documentation (actual programs or their job-specific flow charts) with DDC system. The contractor shall also provide an electronic copy of all as-builds to the OSU Project Manager directly.
  - 1. Manufacturer's Product Data:
    - a. All equipment components
  - 1. Shop Drawings:
    - a. System wiring diagrams with sequence of operation for each system as specified.
    - b. Submit manufacturer's product information on all hardware items along with descriptive literature for all software programs to show compliance with specifications.
    - c. System configuration diagram showing all panel types and locations as well as communications network layout and workstations.

Where installation procedures, or any part thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Associate prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

### 3.04 TRAINING

- A. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 7:00 a.m. to 3:30 p.m. weekdays as follows:
- B. Provide 8 hours of training for FOD Building Automation personnel. Training shall include:
  - 1. Explanation of drawings, operations and maintenance manuals

## APPENDIX A

---

2. Walk-thru of the job to locate control components
  3. Software, peripherals and panel communication procedures.
  4. DDC Controller and ASC operation/function
  5. Operator control functions including graphic generation and field panel programming
  6. Operation of portable operator's terminal
  7. Explanation of adjustment, calibration and replacement procedures
- C. Provide up to 32 hours of additional training at the request of the OSU Project Manager for a period of one year from final completion of the project.
- D. Since the University may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the University requires such training, it will be contracted at a later date. Provide description of available local and factory customer training.

### PART 4 APPENDICES

#### Appendix A.1:

The minimum hardware requirements for the Portable Operator Terminal (POT) are as follows:

- 3 GHz Pentium Processor 32 bit
- 4 GB RAM
- 1 serial port
- 250.0 GB Hard Drive
- 15.4" display
- 2X USB 2.0 Ports
- DVD/CD-RW ROM Drive
- Windows XP Professional or later operating system (A/E verify these requirements with OSU Project Manager)
- Integrated keyboard and pointing device
- 2 battery packs, 110 VAC adapter/charger
- Internal Modem
- Carrying Case
- Three-year limited warranty
- Proprietary Software Key(s)
- Operating System restore software including any Proprietary Software

#### Appendix A.2

Steam Desuperheater Control:

## APPENDIX A

---

Provide a modular controller with associated input/output modules and touch-screen display mounted in a panel located in an area not subjected to high temperature or relative humidity. (Modular controller shall be Delta EnteliBUS eBMGR-TCH, or equivalent by an approved equivalent manufacturer.) Desuperheater control valve shall be as described in Division 23 for medium pressure steam service and shall have electro-pneumatic positioner and Class V shutoff. Provide high temperature sensor and transmitter.

Sensor:

Sensor Type	1000 Ohm +/- 0.1% @ 32 F
Temperature Coefficient	0.00375 Ohm/Ohm/Degree C
Sensitivity	2.1 Ohm/F @ 32 F
Measurement Range	-58 F to 932 F
Probe Material	304 Stainless Steel
Wiring Terminations	Two-wire nickel coated stranded copper, 24 inch long 22 AWG fiberglass insulated
Warranty	3 years
Model Number	S241HC (Minco, or equivalent)

Transmitter:

Supply Voltage	8.5 – 35 VDC unregulated
Sensor Input	1000 Ohm platinum 0.00375 Ohm/Ohm/Degree C
Measurement Range	0 F to 800 F
Signal Output	4 – 20 mA
Maximum Output Impedance	775 Ohm +/- 0.1% @ 24 VDC min
Accuracy	Calibration accuracy +/- 0.05% of span
Operating Temperature	-58 F to 160 F
Well Operating Pressure	3000 PSIG max
Well Material	304 Stainless Steel
Warranty	3 years
Model Number	TT111H-0800 (Minco, or equivalent)

Provide the following inputs and outputs:

Desuperheater Control Valve	Analog Output
Desuperheater Pump 1 Status	Binary Input
Desuperheater Pump 2 Status	Binary Input
Desuperheated Steam Temperature	Analog Input

Desuperheater control valve shall modulate to maintain steam temperature at 15 F above saturation temperature. Provide alarm for high temperature and pump failure.

Desuperheater pump package will be controlled by its own microprocessor controller.

---

END OF APPENDIX A

## APPENDIX B – REQUIREMENTS FOR ACCESS

2006 Edition, Published January 1, 2006; Division Revision Date: April 15, 2015

### REQUIREMENTS TO ASSURE ACCESS FOR INDIVIDUALS WITH DISABILITIES

The University views each construction project as an opportunity to maximize the accessibility and usability of its built environment. Providing and improving access to the built environment should be an integral part of the design and development process. The following Access Requirements are based on the "2010 ADA Standards for Accessible Design", developed by the U.S. Architectural & Transportation Barriers Compliance Board and the Ohio Building Code 2011- Chapter 11 - ICC A117.1-2009:

All numerical references below are to Article and Paragraph numbers in the 2010 ADA Standards as published in the Code of Federal Regulations (28 CFR Part 35.151 and the 2004 ADDAG at 36 CFR part 1191 appendices B and D) September 15, 2010. The 2010 ADA Standards shall be considered part of these standards as if reprinted in full herein. The following revisions and/or additions to ADAAG shall also be part of the University Standards:

101.1, 201.1, 202.1 & 202.5	Proposed departures from the <u>ADA</u> guidelines or University Standards addressing access for individuals with disabilities based on equivalent facilitation (alternative methods of providing equal or greater access), structural impracticability or technical infeasibility shall be submitted in writing and must receive approval of both the University Architect and the ADA Coordinator.
<u>2.06.2.6</u>	<u>Performance Areas. This section should be read to include access to raised lecture podiums.</u>
203.9, 206.2.8 & 215.3	Areas Used Only by Employees as Work Areas. A minimum of five percent (5%) of individual work areas (excluding Elevator pits, elevator penthouses, mechanical rooms, piping or equipment catwalks) should be designed to allow wheel chair maneuvering clearances and reach ranges when furnished and equipped)
<u>215 &amp; 702</u>	Provision of both audible and visible alarms shall be required at all locations where either type is required. <u>EXCEPTION: Fire alarm systems in medical care facilities shall be permitted to be provided in accordance with industry practice.</u>
221	Provide accessible seating as required by the table at 221.2.1.1 Accessible seating shall be located at both the front and rear of the room in all new construction and wherever feasible in renovations.

## APPENDIX B – REQUIREMENTS FOR ACCESS

---

- 403.4 &  
404.2.4.4 At changes in floor elevation, especially subtle changes, provide a readily visible change in color and/or pattern to alert visually impaired (but not blind) individuals to the potential "tripper".
- 404.2.3 Note that nominal 32" doors do not comply. It is recommended that 36" doors be used.
- 404.2.7 Doorknobs shall not be used without prior approval of the University Architect. Provide lever handles. If an exception is provided the Project Manager shall notify the ADA Coordinator.
- 404.3 Add 404.3(1) to read as follows:  
  
"Provide power assisted door operators on all cross-corridor doors occurring in main corridors. If in compliance with applicable code, magnetic door "hold-opens" may be used in lieu of power assisted operators".
- 406.1 Provide ramps at all crosswalks leading to (or from) an accessible area or route. Locate said ramps so as to provide the most direct route possible.
- 406.3 &  
Figure 406.3 Straight-sided ramps are not permitted without prior approval of the University Architect.
- 406 Construction of ramp shall conform to construction requirements for sidewalks in regard to concrete thickness, base thickness, base compaction, etc.
- 407.2.1  
& 309.4 Hall call buttons shall be centered at 36" above finish floor. Call buttons shall not be located on the elevator doorjamb and must be located for easy access by wheelchair-bound users.
- 410 Platform lifts are not permitted in new construction unless approval is granted by the University Architect and the ADA Coordinator. The basis for approval shall be extenuating circumstances, not including aesthetics.
- 602 Drinking fountains shall comply with 307 & 602..
- 604 Water closets & Stalls shall comply with 604.3.
- 604.8.1.1 &  
Figure 604.8.1.1 All wheelchair accessible toilet stalls shall be 60" x 60". Therefore void Figure 604.8.1.1(b) and amend the dimensions on Figure 604.8.1.1(a) to provide a 60" x 60" stall. Note that prior approval by the University Architect and the ADA Coordinator must be obtained to use other stall configurations [such as Figure 604.8.1.1(a)] on remodeling projects only and only where absolutely required by existing conditions.
- 604.8.1.2 Add the following note: All accessible stalls shall have slide latch door hardware.
- 607.6 &  
608.6 Wheelchair accessible tubs and showers shall be equipped with a standard wall-mounted nozzle and a hand-held shower sprayer with a 59" hose minimum. Mount hand-held sprayer at 42" above the bottom of the tub or shower basin. Provide controls that will permit use of either the wall-mounted and hand-held shower sprayers individually or both sprayers at the same time.

**APPENDIX B – REQUIREMENTS FOR ACCESS**

---

603.2.3 Add the following: "All Toilet Rooms, except "private" rooms containing a single water closet, shall be equipped with Push-Pull door hardware. Latches are neither needed nor desired on the doors of multiple fixture Toilet Rooms".

603.2.3(1) Add the following paragraph: "Avoid the use of vestibules with inner and outer doors as access to Toilet Rooms." -.

609.8 Add paragraph 609.9 as follows: "Grab bar fastening system shall be of a concealed type".

ORC Sec. 9.57 Whoever erects or replaces a sign containing the international symbol of access shall use forms of the word "accessible" rather than forms of the word "handicapped" or the word "disabled" whenever words are included on the sign.

END OF APPENDIX B

---



## APPENDIX C

2006 Edition, Published January 1, 2006; Document Revision Date: September 30, 2014

### ENERGY CONSERVATION REPORT - Removed

#### **ENERGY AND SUSTAINABILITY**

##### 1. General

- a. All "Building Construction Projects" shall be required to address the goals of the University's Green Build and Energy Policy 3.10.
- b. "Building Construction Projects" shall be understood to mean new construction, improvement, renovation, enlargement or other alterations to buildings and structures, or part of a building or structure that includes a major energy consuming system, component or equipment.
- c. "Alterations" to an existing building system (egress, building envelope, HVAC, lighting, plumbing, etc.) shall be understood to mean that these changes shall conform to that required for new construction to the extent of the alteration (reference Ohio Building Code 3403.5).

##### 2. Policy 3.10 Energy Compliance Documentation Submittal Requirements

- a. The percent energy improvement for new construction and total renovation projects shall be established by comparing the "concept building" to a "baseline building" using the "Performance Rating Method" established by ASHRAE Standard 90.1-2004, Appendix G. This will require a building energy analysis. The building performance calculations for this analysis shall be accomplished using the computer-based building simulation program approved by the University Engineer. For components that cannot be modeled by the simulation program, the exceptional calculation methods requirements in ASHRAE Standard 90.1, Appendix G may be used.
- b. The percent energy improvement for limited scope "partial" renovation projects, such as, lighting improvements, window replacements, roof replacement, etc., will require special consideration for the calculation methodology approved by the University Engineer.
- c. All Policy 3.10 energy analysis submittals shall be summarized on the OSU Performance Rating Report form.
- d. The Life Cycle Cost Analysis shall be included with the Policy 3.10 compliance submittal to justify the design concepts proposed by the Architect/Engineer (A/E) design team. The energy costs used in the analysis shall be obtained from the OSU Utilities Division Senior Director.
- e. The A/E design team decision related to the "point of use energy source" to produce heat or other energy consuming systems for any building on the OSU main campus or the OSU Medical Center must be established with the approval of the University Engineer and the OSU Utilities Division Senior Director.

---

END OF APPENDIX C

**APPENDIX D**

2006 Edition, Published January 1, 2006; Document Revision Date: January 26, 2011

This section has been incorporated into Division 0 (section 00036).

**REQUIREMENTS FOR SURVEY INFORMATION****General Requirements**

1. All survey work performed on or for The Ohio State University shall be in Ohio State Plane South, NAD83(86), NAVD88 Datum and submitted to the Facilities Operations and Development Survey Group (Campus Surveyor)
2. Cadastral (survey) entities.
  - a. Property Lines: Locate and dimension all property lines and show bearings of same. Include parcel Id's and ownership of same.
  - b. Easements: Clearly and fully describe and delineate all rights, restrictions, easement locations, etc. on or adjacent to the proposed site.
  - c. Right-of-Ways: Clearly and fully describe and delineate all right-of-ways on or adjacent to the proposed site.
3. Utilities: Show and delineate all above and below ground utility routes, and note ownership of same when not owned and maintained by The Ohio State University. Show locations of all utility features such as: utility poles, hydrants, valves, sewer structures, manholes, junction/pull boxes, transformers, switch gear, control boxes, pedestals, meters, regulators, irrigation features, etc.  
Items with special requirements:
  - a. Pipes: (i.e. water, chilled water, etc.) Indicate size and where applicable denote invert elevation, direction of flow and pressure, and top of pipe elevation (if accessible).
  - b. Manholes: Provide the location and elevation of the center of the manhole lid, and elevation of the manhole rim. Provide an elevation at the bottom of the structure plus invert elevations and directions for all pipes entering/exiting the manhole. Provide the structures internal dimensions relative to the access hole, construction material and an estimate of the current condition.
  - c. Electric and Data Communications: Show the size of the duct bank and the conduit configuration. Indicate by means of a section cut or detail which conduits are in use and which are spares, and provide duct bank/conduit elevation (if accessible).
  - d. Tunnels: Indicate internal dimensions, construction material and type. Provide locations of all vents, pipe drops and access points.
4. Topography.
  - a. Bench Marks: Permanent bench marks shall be provided on adjacent structures for future use.
  - b. Spot Grades: Spots grades shall be furnished, as needed, to supplement elevations recorded on topographic features to provide a density of points that are no greater than twenty-five (25) feet apart.
  - c. Contours: A contour map is to be provided at one (1) foot contour intervals with an index contour interval of five (5) feet, unless otherwise noted. All breaks and obstructions shall be provided and accounted for within the contour map.
  - d. Digital Elevation Model: A DEM of points used to create the contour map shall be provided in AutoCAD format. Points shall be grouped onto individual layers according to type.

## APPENDIX E

5. Topographic features: Show and delineate all natural and man-made features, on and adjacent to the proposed site, as to provide the most accurate depiction of the current site conditions.  
Items with special requirements:
  - a. Buildings: Show all building corners and wall planes where they intersect the ground (foot print), and indicate all overhangs and cantilevers (roof print).
  - b. Hardscapes: Show and indicate the extents and material types of all hard surfaces to include; roads, drives, curbs, walls, walks, etc.
  - c. Signage: Indication location, type and verbiage of all signage on or adjacent to the proposed site.
  - d. Paint Markings: show and indicate the location and extents of all paint markings on or adjacent to the proposed site to include; road striping, cross-walks, parking lot lines, etc.
  - e. Vegetation: Show and depict through symbols all trees, shrubs, planting beds, mulch beds and lawn areas. Where trees or shrubs are planted in mass, delineate the extents of the vegetation and label the area as appropriate.
6. Drafting: Electronic drawings shall be prepared and provided at a scale of 1:1 and submitted in AutoCAD format, to include any and all xref's, plot styles and fonts. A hard copy print/plot shall accompany the electronic version and should be provided at a scale of 1" = 40'.
  - a. Electronic and hardcopy drawings should include: a north arrow, title of drawing, symbol legend, name and address of Owner and Surveyor, date, revision designation, scale of drawing and legal title of property.
7. Seal: Affix seal of the Registered Professional Surveyor responsible, and provide signature on all hardcopy plots.

### **Coordination of Underground Utilities Recording during Construction:**

1. Prior to the installation, uncovering or work to any utility (new or existing), the contractor/construction management liaison shall notify the Campus Surveyor of the proposed work, to include type of utility and scope. Provide notification within one (1) business day prior to excavation.
2. After notification, the contractor/construction management liaison shall provide the Campus Surveyor access to the utility, and ensure that the appropriate data collection (survey) has been completed prior to covering the utility. Failure to provide for the appropriate data collection (survey) the contractor may be responsible for the uncovering/excavation of the utility so that its proper location and attributes can be recorded by the Campus Surveyor or his/her representative. Documentation by the contractor/construction management liaison in-lieu of the Campus Surveyor will not be accepted, unless information is provided as indicated below.

### **Use of Consultants/Private Survey Companies to Perform Underground Utilities Recording**

Other than contacting the Campus Surveyor to record the underground utilities installed or encountered during the construction as described as above, projects with significant impacts to university owned and operated utilities; shall include funding for Consultants/Private Survey Companies to perform construction survey work. The scope of the survey work shall be approved by the University Engineer prior to completion of schematic design. All work will be completed within the guidelines identified below.

## APPENDIX E

1. All survey work (utility, topographic, etc.) performed by consultants shall meet all general requirements, listed above.
2. Completed surveys shall be submitted to the Facilities Operations and Development Survey group (Campus Surveyor) as-well-as the appropriate Project Manager or requesting Architect/Engineer (A/E) firm for review. Deliverables shall include an electronic drawing in AutoCAD format, including a layering standard approved by the Campus Surveyor, as well as a hardcopy plot/print. Survey deliverables shall indicate all control points and bench marks used with their corresponding N,E,Z coordinates. An ASCII text file of the collected points shall be provided, as-well-as any field notes (to include sketches and Station Recovery Notes), along with a copy/description of any surveying codes that have not been translated from their original raw data format.
3. Surveys performed by consultants/private survey companies will carry the same notification process as described under "Coordination of Underground Utilities Recording during Construction", listed above. The Campus Surveyor shall be given the opportunity to inspect all new and existing facilities and perform additional data collection at his/her discretion.
4. S.U.E – Any buried utility/facility on the Ohio State Campus that is to be exposed through non-invasive (or any other means) will carry the same notification process as described under "Coordination of Underground Utilities Recording during Construction", listed above.
5. Data collection performed by consultants/private survey companies, without properly notifying the Campus Surveyor, may not be accepted and may result in re-exposing the utility/facility.

---

END OF APPENDIX E

## **APPENDIX F**

2006 Edition, Published January 1, 2006; Document Revision Date: October 19, 2016

### **TITLE SHEET AND TITLE BLOCK STANDARD DRAWINGS**

These Title Sheet and Title Block standard drawings are to be utilized on all projects for Facilities Operations and Development.

Signature blocks to be included should be verified with the Project Manager for the specific project.

Please follow the links below to download the files:

Title Sheet – Local Administration	<a href="#">.dwg</a> <a href="#">.dxf</a>
Title Sheet – State Administration	<a href="#">.dwg</a> <a href="#">.dxf</a>
Title Block – Local Administration	<a href="#">.dwg</a> <a href="#">.dxf</a>
Title Block – State Administration	<a href="#">.dwg</a> <a href="#">.dxf</a>

---

END OF APPENDIX F

**APPENDIX G**

2010 Edition, Published January 1, 2010; Division Revision Date: August 1, 2012

**This section was removed and left blank on purpose:**

**CLEANING, FLUSHING, & WATER TREATMENT PROCEDURE  
FOR BUILDING HYDRONIC SYSTEMS****1.01 GENERAL**

- A. The following Guideline assumes the chemicals for the CFW Procedure (Cleaning, Flushing, and Water Treatment) are provided by the Water Treatment Supplier (WTS) working directly for the University:
1. This Guideline is intended to provide the Project A/E (Architect/Engineer) with general procedural information that is intended to benefit the efficiency and longevity of the University's building closed loop hydronic systems (e.g. heating hot water; chilled water). It is the responsibility of the A/E to adjust the Guideline specifics to meet the needs of the particular Project system. A CFW Procedure should be developed by the A/E and included in the Project Manual for all projects that modify existing or install new Building Hydronic Systems.
  2. The implementation of this CFW Procedure is the responsibility of the Prime Contractor defined by the A/E in the Project Manual.
  3. For standalone building recirculating hydronic systems, recommend to OSU Project Manager whether CFW Procedure should be applied to both new and existing piping or to new piping only. Thoroughly clean and passivate hydronic systems prior to operation of the building systems. For chilled water systems that will be connected to a Campus Central Chiller Plant, all new and existing piping shall be thoroughly cleaned and passivated prior to operation of the building systems and/or circulation to any of the Campus Central Chilled Water Plants (McCracken, East Regional, and South Campus Chiller Plants).
  4. The A/E shall provide the OSU WTS and the Contractor with a calculated water volume (gallons) of the hydronic system(s) for the CFW Procedure and the required flow rate (GPM) to remove debris, slag and/or surface corrosion byproducts.
  5. The Water Treatment Supplier shall submit to the OSU Project Manager, the SDS (Safety Data Sheets) documentation for all chemicals used for the CFW process.
  6. The A/E shall provide a piping system drawing or sketch to identify the hydronic piping system scope of work that will be flushed and cleaned, including bypass or isolation valves to protect equipment that may be damaged during the CFW process. The A/E's drawings shall identify the connections to feed the chemicals and the makeup water as well as the location of the sanitary floor drains to bleed and flush the wastewater used to clean and passivate the pipes. The makeup water source(s) and bleed locations selected shall provide adequate capacity to drain and flush the system within a 4-hour period (or as directed by the OSU Project Manager).



If the existing pipe and valve taps are inadequate, provide new valve connections.

7. The Contractor shall prepare a plan to implement the CFW Procedure and provide a detailed sketch based on the A/E's drawing, showing bypasses, valves, blank-offs, blind flanges, etc., as necessary to accomplish the work. The Contractor shall provide documentation and acceptance of the CFW procedure to the OSU Project Manager. See Exhibit C.

B. Prerequisites for the Process of Cleaning & Flushing:

1. The Contractor shall inform the OSU Office of Environment Health & Safety (EHS) prior to the planned cleaning and flushing process. EHS will serve as the initial and primary contact with the city of Columbus Division of Sewerage and Drainage (DOSD). The required Standard Operating Procedure (SOP) and Pre-Approval documents are attached to this Guideline as Exhibit A and Exhibit B.
2. The chemicals used by the Contractor needs to be in compliance with the City of Columbus; the WTS shall furnish this information to the Contractor and the OSU EHS for their use and disposition.

C. Preparation for Cleaning:

1. Contractor shall install a BYPASS pipe wherever needed between the hydronic return & supply lines to recirculate the entire system using the hydronic pumps installed. The diameter of this pipe shall be at least 1/3 of the diameter of the main hydronic lines. The contractor shall also remove or cap the temporary BYPAS to a permanent configuration (to allow future CFW) when flushing is complete and approved water chemistry is achieved.
2. Contractor shall remove all strainer screens prior to flushing all systems, including mud from the dirt legs. Contractor shall clean and replace/reinstall all strainer screens after the final cleaning and flushing procedure has passed the final test criteria noted herein.
3. Complete circulation must be achieved during the cleaning procedure. The A/E shall develop a CFW PLAN to achieve a minimum velocity of three feet per second (3 ft/s) in the pipes to ensure the cleaning chemicals will work properly. If necessary, isolate parts of the piping system to attain at least (3 ft/s) in piping being flushed. All electric, pneumatic, and thermostatic operated valves shall be full open. All dead end runs shall be looped together with piping not less than one-third the size of the run.

D. Cleaning Chemical (PreKleen-1301 or approved equivalent):

1. The cleaning solution shall be formulated to remove light grease, cutting oils, loose mill scale, organics, and extraneous construction debris. The cleaner shall contain a polyphosphate, an anionic polymer dispersant, and a low-foaming surfactant. Formulations shall not contain any ingredient that may be harmful to system materials of construction and shall be acceptable to the City of Columbus for discharge to the city sanitary sewer system. Sufficient cleaner shall be used to effectively clean and condition all piping so as to promote the formation of a uniform passivating film on all metal surfaces.

E. Pre-Operational Cleaning Procedure:

1. Prior to adding PreKleen-1301, the WTS shall run a conductivity test on a sample of system water. The WTS shall record this reading.
2. Add (PreKleen-1301) directly into the system via a bypass chemical feeder or chemical transfer pump at a dosage rate of 1-2 gallons per 1,000 gallons system volume.
3. After system water has been circulated, WTS shall run a conductivity test on a sample of system water to confirm sufficient cleaner has been added. The conductivity should be 500-1000 mmhos/cm greater than the conductivity reading obtained prior to adding PreKleen-1301. If cleaner concentration is insufficient, add more PreKleen-1301 until concentration is sufficient.
4. After Pre-Kleen 1301 concentration is sufficient, circulate the system water for 48 hours minimum [120 hours maximum].
5. After obtaining permission from OSU EHS, drain the system completely, paying particular attention to mud from drop legs and all low points. If draining quickly is not possible, slowly bleed the system to drain until all the cleaning solution has been removed.
6. Refill the system with clean potable water.
7. Recirculate for 8-12 hours and then completely drain the system again.
8. The WTS shall sample the water and run a conductivity test to determine if the cleaner has been flushed out of the system. The conductivity of the sample should be approximately the same as city water conductivity indicating the cleaner has been removed from the system. If necessary, bleed the system to drain until the conductivity approximates the city water conductivity.
9. Test Criteria Requirements - WTS shall sample the water to determine the following:
  - a. TDS levels should be less than 3500

- b. pH level should be between 9 to 11
  - c. ATP should be <75. Determine bacteria activity by running ATP tests. If ATP (Alive) value exceeds 75, biocide should be added to kill bacteria. Micro Control 15N, or approved equivalent, at a dosage of (1) pint per 1,000 gallons volume should be added and circulated for 24 hours. Resample and run ATP tests again to confirm bacteria kill.
  - d. Iron levels should be <1.0 ppm, If the iron concentration is >1.0 ppm, Contractor shall continue flushing the system with clean potable water until it is <1.0 ppm.
10. After WTS confirms that the system meet the required test criteria, Contractor shall reinstall all strainers and add the corrosion inhibitor: (5) gallons of CorrPro-1380, or approved equivalent, per 1,000 gallons system volume to develop 500-1000 ppm nitrite as NO<sub>2</sub>. The length of time between the completion of the cleaning procedure and the addition of the corrosion inhibitor shall not exceed (24) hours.

# Exhibit A

## **The Ohio State University** *Slug Discharges Standard Operating Procedure*

Janice Fry

Date of Revision: 18 November 2014

**The Ohio State University**  
**Office of Environmental Health & Safety**  
1314 Kinnear Road  
Columbus, OH 43212  
Phone: (614) 292-1284  
Fax: (614) 292-6404  
[www.ehs.osu.edu](http://www.ehs.osu.edu)

## 1.02 DISCHARGES

### A. Introduction:

This document outlines the steps to take for slug discharges to the sanitary sewer. A slug discharge is any non-routine discharge to the sanitary sewer, whether the discharge is planned or an accidental release, at a flow rate or concentration that could cause a violation of prohibited discharge standards. The most common types of planned slug discharges are from cleaning and flushing of water lines, tanks, or boilers.

### B. Planned Discharges:

1. Planned slug discharges to the sanitary sewer require pre-approval from the City of Columbus Division of Sewerage and Drainage (DOSD) Pretreatment Office. EHS will serve as the primary contact with the DOSD.

### C. The project manager or supervisor of any project that proposes discharging water to the sanitary sewer shall contact the Environmental Safety and Health (EHS) Environmental Affairs Office as soon as possible in advance of the planned discharge. The primary EHS contacts for discharges to the sanitary sewer are:

Janice Fry	(614) 292-3223
Kent Halloran	(614) 292-5529
Tom Novotny	(614) 688-1764

### D. The following information is needed prior to notifying DOSD:

1. Proposed date(s) of discharge,
2. Proposed total volume and rate of discharge,
3. Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) of all chemicals known to be in the discharge,
4. Estimated concentrations of the chemicals in the discharge, and
5. Any other available information regarding the expected nature of the discharge, such as pH, dissolved solids, metals, temperature, etc.

See Attachment 1 for a form to record all the necessary information needed for DOSD approval. The form should be completed and returned to EHS.

The DOSD may require that the discharge be analyzed for specific pollutants of concern prior to granting approval. These specific pollutants and concentrations limits not to be exceeded are listed in Table 1.

Table 1. City of Columbus Division of Sewerage and Drains Discharge Limits

<b>Pollutant</b>	<b>Discharge Limit (ug/L)</b>
Arsenic	1,000
Beryllium	Non detect
Cadmium	500
Chromium	20,000
Chromium, hexavalent	No limit
Copper	2,700
Cyanide	5,000
Hydrocarbon fats, oil, and grease (FOG)	200,000
Phenol	No limit
Bis(2ethylhexyl)Phthalate	No limit
Lead	4,000
Mercury	20
Molybdenum	No limit
Nickel	5,000
Selenium	10,000
Silver	3,000
Zinc	5,500

The DOSD will consider other known pollutants in the planned discharge on a case by case basis.

Once the DOSD has approved the discharge, the discharge must not occur before, during, or immediately after a significant rain or snow melt event. The DOSD should be consulted regarding the timing of the discharge if wet weather or snow melt is a factor.

E. Instructions for Obtaining DOSD Approval of Planned Discharges:

1. The primary DOSD contact for approval of planned discharges is Jim Carpenter at (614) 645-1942.
2. If no one is available at that number, the secondary contact number for DOSD is (614) 645-5876. If no one is available at either number, leave a brief message.
3. If an immediate response is required, contact the Jackson Pike Wastewater Treatment Plant Supervisor's office at (614) 645-3138 (extension-2) to obtain permission prior to discharge.

4. Record the name of the wastewater treatment plant supervisor that granted permission for the discharge.
5. Immediate email follow-up to [joc@columbus.gov](mailto:joc@columbus.gov) and [pretreatment@columbus.gov](mailto:pretreatment@columbus.gov) is also required. Include information regarding the nature and volume of the discharge, the date and time of discharge, and the name of the wastewater treatment plant supervisor that granted permission to discharge.
6. Attach files of the applicable MSDSs or SDSs to the email.
7. A cc: of this email should be addressed to:

Janice Fry	<a href="mailto:fry.71@osu.edu">fry.71@osu.edu</a>
Kent Halloran	<a href="mailto:halloran.21@osu.edu">halloran.21@osu.edu</a>
Tom Novotny	<a href="mailto:novotny.66@osu.edu">novotny.66@osu.edu</a>

F. Pre-Approved Routine Discharges:

1. The McCracken Power Plant's routine discharges (boiler blowdown, spent brine from water polishers and softeners, etc.) are allowed under the McCracken Power Plant's Slug Control Plan as approved by the DOSD.

G. Prohibited Discharges:

1. Prohibited Sanitary Sewer Discharges:

Section 1145.20 of the City of Columbus municipal Code of Ordinances prohibits specific types of discharges to the sanitary sewer, including, but not limited to:

- a. Solid or viscous substances, including oils of any kind
- b. Flammable or explosive substances
- c. Any discharge that will cause the sewage temperature in the public sewer to be above one hundred twenty (120) degrees Fahrenheit (forty-nine (49) degrees C) after mixing with other flow in the public sewer at the nearest accessible point downstream from the user, or above one hundred four (104) degrees Fahrenheit (forty (40) degrees C) at the influent to the POTW treatment facility, or above one hundred sixty (160) degrees Fahrenheit (seventy-one (71) degrees C) in the user's sewer at the nearest accessible point upstream from confluence with the public sewer system.
- d. Corrosive substances
- e. Any discharge with a pH below 5.0 S.U. or above 12.5 S.U.
- f. Oxygen-demanding pollutants (biochemical oxygen demand (BOD), etc.)
- g. Toxic or poisonous substances
- h. Radioactive wastes
- i. Wastes regulated under the Resource Conservation and Recovery Act (RCRA)

2. Prohibited Storm Sewer Discharges:

- a. Planned discharges to the storm sewer are not allowed under any circumstances.  
Contact EHS immediately if an accidental release to the storm sewer has occurred. The primary EHS contacts for accidental discharges to the storm sewer are:

Kent Halloran	(614) 292-5529
Tom Novotny	(614) 688-1764
EHS 24-hr Emergency Response	(614) 292-1284 (option#1, then select option#2)

3. Unplanned Discharges:

- a. Immediate notification to the DOSD is required if an unplanned slug discharge has occurred.
- b. An EHS representative will immediately notify the Pretreatment Section of the City of Columbus DOSD at 645-5876 of any unplanned non-routine discharge to the sanitary sewer system.
- c. This is required to enable the wastewater treatment plant to take appropriate countermeasures to minimize potential risk to the wastewater treatment workers, damage to the wastewater treatment system, and/or the receiving waters.
- d. In the event of an unplanned slug discharge, all appropriate MSDSs or SDSs will be consulted to provide the wastewater treatment plant with timely information.
- e. If no one is available at DOSD to accept the telephone notification, the EHS representative will call the DOSD Sewer Maintenance Section at (614) 645-7102, which is answered 24 hours / day.

4. A follow up report must be written and submitted to the Pretreatment Department by EHS within five (5) calendar days of the incident. The report shall contain the following:

- a. A description of the discharge
- b. The cause of the discharge
- c. The exact dates and times of the discharge, and if the discharge continues, the time by which the discharge is expected to be corrected.
- d. Any and all steps taken, or to be taken, to reduce, eliminate, and prevent recurrence.

5. See Attachment 2 for a template of a follow up notification letter to DOSD.

The written report shall be sent to:

City of Columbus  
Division of Sewerage and Drainage  
Pretreatment Section  
1250 Fairwood Avenue  
Columbus, Ohio 43206-3372



**Pre-Approval Information for Slug Discharge to Sanitary Sewer**

The City of Columbus Division of Sewerage and Drainage (DOSD) requires pre-approval of non-routine slug discharges to the sanitary sewer. To expedite the approval process, the project manager should complete this form with all the required information and return to EHS along with Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) of any chemicals known to be in the discharge. EHS will notify the project manager when the DOSD approves the discharge. No discharges may occur prior to DOSD approval. Actual approved discharge may be subject to delay in the event of significant rain or snow melt events.

Description of process necessitating discharge to sanitary: \_\_\_\_\_

Project Manager name/contact information: \_\_\_\_\_

Location of proposed discharge: \_\_\_\_\_

Proposed date(s) and time of discharge: \_\_\_\_\_

Proposed total volume of discharge: \_\_\_\_\_

Anticipated rate of discharge: \_\_\_\_\_

Estimated concentrations of any chemicals in the discharge: \_\_\_\_\_

Any other available information regarding the expected nature of the discharge, such as pH, dissolved solids, metals, temperature, etc.

---

Return the completed form to either:

Janice Fry  
[fry.71@osu.edu](mailto:fry.71@osu.edu)  
138 McCracken Power Plant  
2003 Millikin Rd  
Columbus, OH 43210  
614-292-3223

Kent Halloran  
[halloran.21@osu.edu](mailto:halloran.21@osu.edu)  
1314 Kinnear Rd  
Room 106  
Columbus, OH 43212  
614-292-5529

{Date}

Mr. Jeff Bertacchi  
Pretreatment Program Manager  
Division of Sewerage and Drainage  
1250 Fairwood Avenue  
Columbus, OH 43206-3372

Dear Mr. Bertacchi,

This letter serves as a written follow up to a telephone notification made to {insert name of DOSD employee who took the telephone report} of the Division of Sewerage and Drains on {insert date of telephone notification} regarding an unplanned slug discharge from The Ohio State University to the sanitary sewer.

The unplanned discharge occurred on {insert date}, at approximately {insert time} and consisted of approximately {insert volume} of wastewater from {insert description of process or source of wastewater discharged}, containing {insert any known constituents of concern}.

This discharge was caused by {insert description of cause}. The Ohio State University has implemented the following measures to prevent a recurrence of this discharge: {insert description of corrective action taken}. [Optional text, if applicable: {Attached are MSDSs of the known constituents in the discharge.}]

Please contact me at 614-{insert phone number} or {insert email address} if you require additional information.

Sincerely,  
{insert signature}

{insert name}  
{insert title}

cc: Tom Novotny  
Mike St. Clair

# Exhibit B

## The Ohio State University

### *Pre-Approval Information for Slug Discharge to Sanitary Sewer*

Janice Fry

Date of Revision: 18 November 2014

**The Ohio State University**  
**Office of Environmental Health & Safety**  
1314 Kinnear Road  
Columbus, OH 43212  
Phone: (614) 292-1284  
Fax: (614) 292-6404  
[www.ehs.osu.edu](http://www.ehs.osu.edu)

### 1.03 PRE-APPROVAL // SLUG DISCHARGE

The City of Columbus Division of Sewerage and Drainage (DOSD) requires pre-approval of non-routine slug discharges to the sanitary sewer. To expedite the approval process, complete this form with all the required information and return to EHS along with Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) of any chemicals known to be in the discharge. EHS will notify the project manager when the DOSD approves the discharge. No discharges may occur prior to DOSD approval. Actual approved discharge may be subject to delay in the event of significant rain or snow melt events.

Description of process necessitating discharge to sanitary: \_\_\_\_\_

Project Manager name/contact information: \_\_\_\_\_

Location of proposed discharge: \_\_\_\_\_

Proposed date(s) and time of discharge: \_\_\_\_\_

Proposed total volume of discharge: \_\_\_\_\_

Anticipated rate of discharge: \_\_\_\_\_

Estimated concentrations of any chemicals in the discharge: \_\_\_\_\_

Any other available information regarding the expected nature of the discharge, such as pH, dissolved solids, metals, temperature, etc.

---

Return the completed form to either:

Janice Fry  
[fry.71@osu.edu](mailto:fry.71@osu.edu)  
138 McCracken Power Plant  
2003 Millikin Rd  
Columbus, OH 43210  
614-292-3223

Kent Halloran  
[halloran.21@osu.edu](mailto:halloran.21@osu.edu)  
1314 Kinnear Rd  
Room 106  
Columbus, OH 43212  
614-292-5529

# Exhibit C

## **The Ohio State University** *Hydronic System Cleaning, Flushing Water Treatment*

Janice Fry

Date of Revision: 18 November 2014

**The Ohio State University**  
**Office of Environmental Health & Safety**  
1314 Kinnear Road  
Columbus, OH 43212  
Phone: (614) 292-1284  
Fax: (614) 292-6404  
[www.ehs.osu.edu](http://www.ehs.osu.edu)

**1.04 CLEANING // FLUSHING // WATER TREATMENT - COMPLETION**

The Contractor and OSU Project Manager must execute this form at the completion of the CFW (Cleaning/Flushing/Water Treatment) process. The Contractor shall include this Form, and all attachments, in the O&M manual and Systems Manual.

Comments:	
Inspected by: Date	Reviewed and Approved by: Date (With Conditions)
Signatures	
Final Inspection by: Date (Conditional Approval)	Final Review and Approval by: Date
Signatures	

**APPENDIX H**

2006 Edition, Published January 1, 2006; Document Revision Date: July 22, 2011

**This section was removed and left blank on purpose:**

**APPENDIX I**

2006 Edition, Published January 1, 2006; Document Revision Date: January 1, 2006

**EXAMPLES OF PILING COST CALCULATIONS**

(Refer to Paragraph 31 60 00 regarding payment for piles or caissons)

Contractor indicates added footage at \$10.00/foot and deducted footage at \$8.00/foot.

<u>Example 1.</u>	<u>Piling</u>	<u>Add</u>	<u>Deduct</u>
	#1a	3 feet	
	#3d		12 feet
	#7b	34 feet	
	Total	<u>37 feet</u>	<u>12 feet</u>

Method A:  $37 - 12 = 25$  feet at \$10.00 = \$250.00 added cost.

as opposed to:

<u>Method B:</u>	37 feet at \$10.00 =	\$370.00	
	12 feet at \$8.00 =	96.00	
		<u>\$274.00</u>	added cost.

<u>Example 2.</u>	<u>Piling</u>	<u>Add</u>	<u>Deduct</u>
	#1a		3 feet
	#3d	12 feet	
	#7b		34 feet
	Total	<u>12 feet</u>	<u>37 feet</u>

Method A:  $37 - 12 = 25$  feet at \$8.00 = \$200.00 credit

as opposed to:

<u>Method B:</u>	37 feet at \$8.00 =	\$296.00	
	12 feet at \$10.00 =	120.00	
		<u>\$176.00</u>	credit

---

END OF APPENDIX I



**APPENDIX J**2006 Edition, Published January 1, 2006; Document Revision Date: July 1, 1996

---

**RANGES OF DESIGN LIMITS FOR SOUND CONTROL**

<u>Type of Room or Area</u>	<u>Range of A-Sound Levels in Decibels</u>	<u>Range of NC Criteria Curves</u>
<b>AUDITORIUMS</b>		
Concert and Music Halls	25-35	20-25
Lecture Halls and Auditorium	35-45	30-35
Multi Purpose Halls and Theaters	30-40	25-30
<b>CIRCULATION</b>		
Corridors, Lobbies, and Waiting Rooms	40-50	35-45
Wash Rooms and Toilets	45-55	40-45
<b>CLASS ROOM AND STUDY AREAS</b>		
Class Rooms	35-45	30-40
Conference Rooms, Seminar Rooms	30-40	25-35
<b>DINING AREAS</b>		
Cafeterias	45-55	40-50
Dining Rooms	35-45	30-40
Restaurants	40-50	35-45
<b>LABORATORIES</b>		
Laboratory Class Rooms	40-50	35-45
Processing Laboratories	40-50	35-45
Research Laboratories	40-50	35-45
<b>LIBRARIES</b>		
	35-45	30-40
<b>OFFICES</b>		
Executive Offices	35-45	30-40
General Offices and Reception Rooms	35-50	30-45
Open Offices and Drafting Rooms	40-55	35-50

RECREATION

Gymnasiums, Bowling Alleys, Squash and Hand Ball Courts	40-50	35-45
Recreation Halls and Rooms	40-55	35-50
Sports Arenas	35-45	30-40
Swimming Pools	45-60	40-55

STUDY AREAS

Auto Tutorial Study Carrel Rooms,  
Closed Study Carrels, and Study  
Rooms and Lounges

35-45	30-40
Range of	Range of
A-Sound Levels	NC Criteria
<u>in Decibels</u>	<u>Curves</u>

Type of Room or Area

STUDIOS

Sound Reproduction Studios	30-40	25-30
Television Studios	35-45	30-35

MISCELLANEOUS

Computer Machine Rooms	45-65	40-60
Dormitory Sleeping Rooms	35-45	30-40
Kitchens and Laundries	45-55	40-50
Museums, Court Rooms	35-45	30-40

---

END OF APPENDIX J

## APPENDIX K

2006 Edition, Published January 1, 2006; Document Revision Date: July 1, 1996

### TECHNICAL PROVISIONS FOR CORROSION-SCALE INHIBITORS, MICROBIOCIDES, AND WATER ANALYSIS SERVICES FOR COOLING TOWERS

#### 1. SCOPE

This specification covers the materials, field service, lab service, and technical assistance required for first class treatment of water used in open recirculating condenser systems.

#### 2. MATERIAL DESCRIPTION

.1 The treatment shall be a one (1) component system for the control of scale, corrosion, and fouling caused by air borne debris. The chemical treatment level in the bleed-off shall meet the criteria established by the State of Ohio for discharge directly into streams. The supplier must supply BOD and COD information. The treatment shall be a synthetic organic containing no inorganic pollutants such as chromates, zinc, and phosphates. The treatment shall contain not only a scale inhibitor, but shall contain an antifoulant to keep suspended matter in suspension. The treatment shall have no detrimental affect on wood and shall not require the addition or use of acid to reduce the pH and total alkalinity.

.2 The treatment shall provide corrosion protection for copper, admiralty brass, steel, and galvanized steel, with corrosion rates not to exceed 1 mil per year when applied at "use" concentrations in local city water.

.3 The material shall not deteriorate, breakdown in any way, or precipitate when stored for a period of one (1) year. No deposits shall appear in the line from the drum to the pump and from the pump to where material is introduced into the water being treated.

.4 All material bid shall have the following physical characteristics:

Appearance	Color Optional
Form	Free Flowing Liquid
Freezing Point	5 degrees F.
Flash Point	None
Density	10 Pounds Per Gallon Minimum

.5 Type of Container: The material is to be furnished in 30 gallon drums of steel or suitable plastic. The drums shall have 2" and 3/4" top bung. The supplier shall furnish product number, brand name, and weight of 30 gallon drum for all products quoted.

.6 The selection and application of chemicals for water treatment shall be based on the most efficient use of energy, water, equipment, manpower, and materials. Heat exchange surfaces will be maintained with minimum resistance to heat transfer. Solids will be maintained in suspension for maximum concentration without deposit build-up. The supplier will make specific recommendations regarding the type and quantity of his products to be used to meet the requirement of this paragraph and other applicable sections of this specification.

.7 The treatment in the cooling tower water shall inhibit the formation of deposits in the heat exchanger in which it is flowing, when the material on the other side of the exchanger is as high as 275 degrees F.

.8 The chemical treatment shall be a proven, commercially available product.

2. MATERIAL DESCRIPTION (Cont'd)

- .9 The supplier shall furnish a sufficient number of corrosion test coupons to test each tower. They shall be a mild steel. They shall be inserted into the systems at points being representative of conditions within the system. The contractor is to determine these locations, which shall be approved by The Ohio State University.

The coupons shall be of standard size, have identification numbers stamped into the surface, have mounting holes, and be supplied with insulated mounting plugs. They shall be preweighed to the nearest 0.1 milligram. The corrosion rate shall not exceed 1 mil per year. Corrosion test results must contain a photograph of test strip and the formula used in the calculations for determining the mils per year corrosion rate. Corrosion strips must be supplied preweighed, with weight supplied for each fresh strip. The coupons or strips are to be checked at 60 day intervals, or more frequent if there is reason to suspect high corrosion rate. The maximum time permitted for corrosion results to be returned to the University is forty (40) days from the date of removal from system. The coupons are to be provided at no cost to the University.

- .10 Two completely different non-oxidizing microbiocides shall be supplied for an alternating program of microorganism control. They shall be broad spectrum microbiocides. The microbiocides shall be non-foaming and shall not affect or reduce the operating efficiency of the system. The microbiocides shall be effective within the 30-80 p.p.m. range, with dosage not to exceed 200 p.p.m. In the event that microbiocides do not produce microorganism control, non-foaming alternates must be supplied at no cost to the University.
- .11 The microbiocides can be in briquette form or liquid or a combination of briquette and liquid.
- .12 Product bulletins or brochures shall be furnished for each product recommended. OSHA safety data sheets shall be submitted for each product quoted. These data sheets shall accompany the bid documents.

3. WATER ANALYSIS AND SERVICE

- .1 Furnish a one year service program by a qualified service person, performing service on a full time basis. Service calls will be scheduled on a twice a month schedule coordinated with the University as to the day of the month that service will be performed. Upon arriving on campus, the service person will contact the University Representative. Upon completion of the service call, a copy of the service report will be given to that representative. Response to emergency service calls shall be less than 24 hours. The University shall make the equipment available to the service person so as not to cause delays.
- .2 The chemical company shall supervise the installation wiring and operation of the chemical feed equipment.
- .3 The mechanical contractor shall notify the chemical company one week prior to system start up. The system is not to be started unless chemicals are on hand.
- .4 As soon as it can be coordinated with the University maintenance personnel, a minimum of four hours training session of theory and operation of the chemical treatment system will be scheduled.
- .5 The electrical contractor will furnish and install all necessary wiring. Power for condenser water treatment shall be 120V single phase taken from auxiliary contacts on the condenser pump starter. Wiring and proper operation will be under the supervision of the chemical company.

3. WATER ANALYSIS AND SERVICE (Cont'd)

.6 If condenser tubes are not free of scale at the end of the operating year, the chemical company will clean the system at no cost to the University.

.7 It will be the responsibility of the chemical company to service the tower and set all controls for a period of one year from start up. It will not be the responsibility of The Ohio State University to maintain this operation.

4. WATER ANALYSIS - CITY OF COLUMBUS WATER

The following city water analysis data is to be used as the basis for determining the amount and type of chemical treatment required.

	<u>City Water</u>
Total Hardness, CaCO <sub>3</sub>	100
Calcium, CaCO <sub>3</sub> , PPM	60
Magnesium, CaCO <sub>3</sub> , PPM	40
Phenolphthalein Alkalinity, CaCO <sub>3</sub> PPM	0
Methyl Orange Alkalinity, CaCO <sub>3</sub> PPM	35
Chloride, Cl <sup>-</sup> , PPM	20
Silica, SiO <sub>2</sub>	6
pH	8
Specific Conductance, Micromhos, 25 degree C	240
Iron as Fe, PPM	0.001

---

END OF APPENDIX K

## APPENDIX L

2006 Edition, Published January 1, 2006; Document Revision Date: January 1, 2006

### THE OHIO STATE UNIVERSITY SAMPLE SPECIFICATION CONDENSER WATER TREATMENT SYSTEM

#### 1. GENERAL

##### .1 REFERENCE

Section 23 63 05, Condensers.

##### .2 SCOPE OF WORK INCLUDED

- .2.1 Furnish and install water treatment systems for the chemical treatment of all condenser water systems shown on the drawings or implied in the specifications.
- .2.2 Provide a chemical treatment system for all closed loop systems described or shown on the drawings.
- .2.3 Contractor shall include in his bid, the cost of chemicals, and service contract for one year from the date of system start up as described herein.

#### 2. PRODUCTS

##### .1 CONDENSER WATER TREATMENT

- .1.1 Provide one impulse water meter on a make up water line to each tower. Meter will be of bronze body type by Rockwell, Badger or Hershey. Plastic will not be accepted. It shall consist of a bronze body impulse water meter. All water meters shall be mounted no higher than 5' off the floor, with the register in full view. It shall register in cubic feet.
- .1.2 Each chemical system shall be a Morr Control wired duplex function controller in a metal, lockable cabinet with an on-off manual switch, test switch, power, and function indicating lights visible when the door is closed. Provide a duplex receptacle in the bottom of the panel. Each system will include an injection assembly and a magnetrol bleed valve model #18-A-23-V with in-line strainer. (Size indicated on drawing.) Chemical pump shall be LMI Model A111 capable of pumping .48 to 24 gpd at 75psi, 120/60/1. All parts in contact with a chemical solution shall be impervious to solutions used in cooling tower treatment. Pump shall incorporate an anti-siphon pressure relief valve.
- .1.3 Solids in the condenser water system shall be controlled by a JA-12-G-7-C-M3 (OSU) Morr controller. This unit will receive a signal from a quick disconnect probe, piped across the condenser pump. The dial model shall be a full linear scale, 0-3000 micro-Mho's of conductance. The controller shall provide a proportional linear output signal of 4 to 20 ma to the central building automation system. The controller shall contain a 15 amp relay to handle a chemical feed pump as well as the bleed solenoid. The unit is to be pre-wired with a duplex receptacle in the bottom of the cabinet.
- .1.4 See attached specification for Cooling Tower Water Treatment.
- .1.5 Furnish one test kit with all necessary apparatus and reagents to perform all required tests on the condenser water system necessary for proper control and monitoring. The test kit shall include a portable conductivity meter plus iron and copper test kits to monitor corrosion.

2. PRODUCTS (Cont'd)

.1 CONDENSER WATER TREATMENT (Cont'd)

- .1.6 Adequate sizing and operation of the control system and the chemical pumps shall be the responsibility of the chemical company.

.2 CLOSED LOOP SYSTEMS

- .2.1 The chemical treatment for the closed loop systems shall be nitrite based on the following:

- .2.1.1 The nitrite water treatment for the chilled water system shall be a liquid treatment, with an active ingredient range of 10 percent minimum to 35 percent maximum of nitrite, by weight.

It is the intent to maintain a nitrite level of 1000 PPM in the chilled water system. It shall incorporate selected alkalinity builders, dispersers, and buffers. The material shall give effective protection against corrosion of brass, steel, copper, cast iron, and solder.

The treatment must stay in suspension for one year in the shipping container without agitation. The product will be shot-fed in the chilled water system.

- .2.1.2 The treatment shall have no corroding or disintegrating effect on gaskets and pump seals.

- .2.1.3 The product shall meet F.D.A. and E.P.A. acceptance.

- .2.1.4 The material shall have the following characteristics:

Appearance	Color
Optional	Form
Free Flowing	Liquid
Density	9.3 pounds/gallon
Flash Point	None

- .2.1.5 Control levels shall be maintained at 1000 to 1200 ppm of nitrite. Chromates and phosphates will not be accepted.

- .2.2 Feed equipment shall consist of a shot-feeder piped across the circulation pumps with quarter turn ball valves on each side of the shot-feeder. Arrange piping so the feeder will be functional when any one of the condenser pumps is in operation. The feeder shall consist of two gallon cast steel body, funnel and valve, with drain and vent cocks. Piping and installation by this contractor.

- .2.3 Provide nitrite and pH test kits in the system test kit.

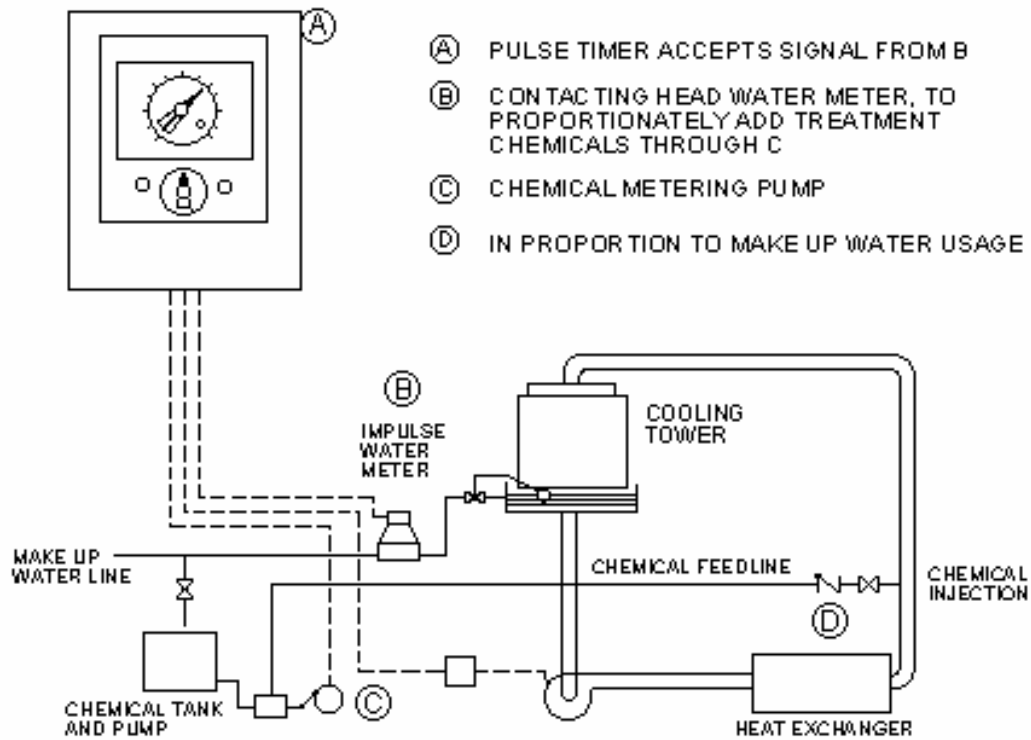
- .2.4 Treatment and equipment similar and equal in all aspects may be furnished by Vulcan, Calgon, Betz, Chardon, or Columbus Technical Services at the contractor's option.

3. INSTALLATION

- .1 Furnish and install all mounts, piping, tubing and valves necessary to install the complete operable water treatment system as shown on the drawings and under the supervision of the chemical company.

3. INSTALLATION (Cont'd)

**TYPICAL INSTALLATION - PULSE TIMER**  
PROPORTIONAL CHEMICAL FEED DUAL TIMER IN A COOLING TOWER





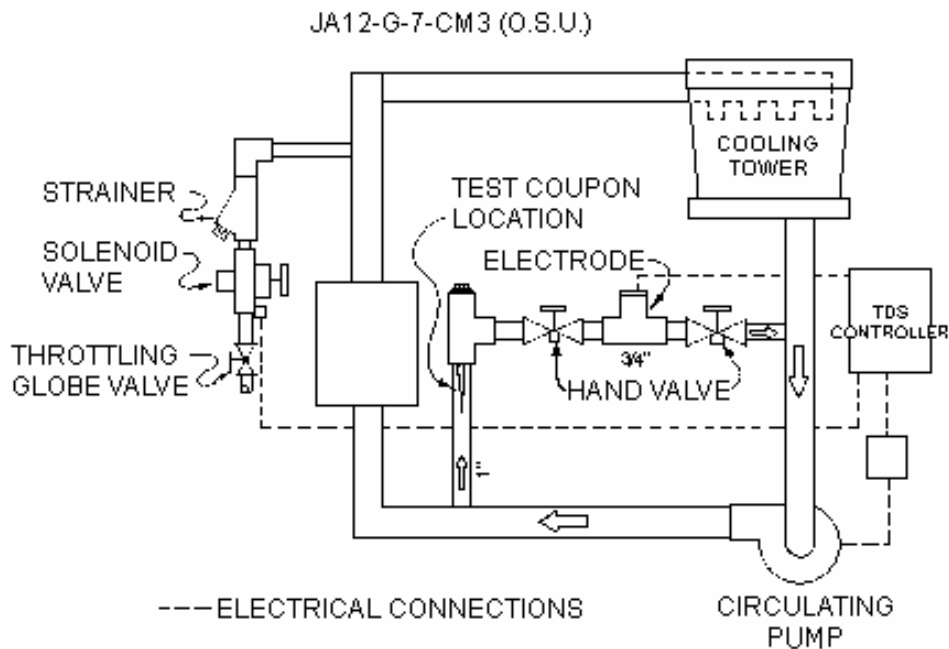


FIGURE 1 - TYPICAL INSTALLATION

Figure 1: Normal installation, with electrode installed in a bypass line across the tower recirculating pump. Hand valves are installed to facilitate removal of electrode for periodic cleaning or inspection.

- A. The power to the Ac/Trol unit is shown connected to the main cooling water circulating pump. Power should be supplied to the unit in this manner so the controller functions only when the system is in operation.
- B. The solenoid valve used should be 115 VAC with a minimum of 5 psi and a maximum of 125 psi pressure at this point. It should have a hand valve for flow throttling.
- C. The normal operation will be bleed-off only from the TDS controllers. Should there be a failure of the probe or internal operation of the TDS controller, the solenoid valve electric power can be unplugged and plugged into a dual timer.
- D. The normal operation of the dual timer is to take an impulse signal from the water meter and send a signal to the chemical pump to inject chemicals should the impulse meter or timers fail, the chemical pump can be unplugged and plugged into the TDS controller for feed and bleed.
- E. When installing the water meter, it is recommended that provisions be made for a backflow preventer or an air gap must be provided, in-line strainer, and manually operated bypass.

---

END OF APPENDIX L

## **APPENDIX M**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **THE OHIO STATE UNIVERSITY COMMUNICATIONS WIRING STANDARD**

The objective of the standard wiring plan for the University is to provide an acceptable outlet for any communication device that requires connection to other devices, networks, or information services serving general University needs. The establishment of a standard wiring plan will support most communication devices and provide a standard by which buildings should be wired. Renovations and network upgrades should be developed following this standard to provide a uniform connectivity guideline for the whole campus community.

The purpose of this document is to provide guidelines by which the communications needs of the University can be met. These guidelines are to be used as a means to provide minimum requirements. Specific requirements for each project will be coordinated with the using agency and an OCIO Telecommunications and Networking representative during project development.

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **INDEX**

<b>SECTION</b>	<b>TITLE</b>	<b>Page</b>
I	Guidelines for Communication Outlets	3
II	Cable and Wire Facilities	5
III	Main and Intermediate Distribution Frames	7
IV	Cable, Wire, and Outlet Installation	9
V	Outside Plant Standards	19
VI	Definitions	25

### **EXHIBITS**

- A. Typical Riser and MDF Plan
- B. Pull and Splice Boxes
- C. Recommended Sizes of Pull Boxes and Splice Boxes
- D. Conduit Size - Minimum Bend Radius
- E. Conduit Fill Capacity and D Rating Chart
- F. Typical MDF Layout 66 style blocks
- G. Typical IDF Layout 66 style blocks.
- H. Pair Color Code
- I. Binder Group Color Code
- J. Jack Color Code
- K. Wireless AP's
- L. Example of Outlet and Face plate
- M. Typical Relay Rack Layout
- O. Typical MDF Layout 110 style blocks.
- P. Typical IDF Layout 110 style blocks.
- Q. Ground TBB Chart
- R. Elevator Room Outlet.
- S. Netshelter

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **SECTION I**

#### **Guidelines for Communication Outlets**

##### **GENERAL**

Guidelines concerning the number of communication outlets by room type are outlined below. Specific requirements for each room and each project shall be coordinated with the using agency at the onset of design for renovation and new construction projects and prior to the initiation of work orders, contracts, or other installation action for other types of projects. The architect/engineer for major renovation and new construction projects should be aware that the Program of Requirements might not be all-inclusive regarding communication facilities. Therefore, the project architect/engineer must work very closely with the appropriate using agency, Academic Technologies Service, Classroom Support, and an OCIO Telecommunications and Networking representative during initial planning to ensure total coordination and minimize the need for revisions during the design development phase. Sections IV and V also contain data of concern to the project architect/engineer. This guideline is limited to minimal standards for the wiring and wiring path only. Ancillary devices such as (but not limited to) phones, modems, ethernet hubs, baluns, and electronic devices are the responsibility of the user.

##### **TERMINATIONS**

#### **1. Faculty/Administrative Offices, Clerical/Staff Offices, Secretary/Administrative Assistant Offices**

Two duplex communications outlets (jacks) for offices with fixed walls of 75 square feet or more are required. One additional duplex outlet for each additional 75 square feet of office space or each additional occupant is required. For offices designed with modular furniture each cubicle or workstation will be provided with one duplex communication outlet per designated occupant. Additionally, a set of station wires (one voice and one data) will be installed as spare to each cluster of 6 office cubicles.

#### **2. Classrooms/Lecture Halls/Auditoriums**

In Classrooms, Lecture Halls and Auditoriums four communication outlets (one on each wall) are required. The need for a cable TV outlet will be considered during the planning process. The cable TV outlet is not intended to solve all audio/video needs in Classrooms Lecture Halls and Auditoriums. Specialized audio/video needs should be coordinated on a per project basis with Academic Technologies Service, Classroom Support. Classrooms may be designed to be subdivided, by adding or removing walls, in the future. If this is a design consideration, the number and location of communication outlets will be adjusted accordingly.

The recommended location for outlets is as follows:

- 1) Chalkboard area
- 2) Projection booth/rear wall
- 3) Lectern area
- 4) Remaining sides

#### **3. Laboratories**

One single wall phone outlet and one duplex communication outlet.

#### **4. Graduate Student Offices**

One duplex communication outlet for every 75 square feet of space. Above 200 square feet one duplex communication outlet on each wall is required.

#### **5. Residence Halls**

One voice jack for RA and hallways, one data jack per student, and one cable TV (or IPTV) outlet in each room.

#### **6. Patient Care Rooms**

One duplex communication and one cable TV (or IPTV) outlet for each occupant.

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **7. Conference Rooms**

One duplex communication and one cable TV outlet in each room. Rooms with more than 500 square feet should have two duplex communication outlets.

### **8. Storage Areas**

One wall-phone communication outlet for each room over 500 square feet and one additional outlet for each additional 2000 square feet are required.

### **9. Libraries**

Libraries will be wired in accordance with the size of the room and need for communication. A minimum of 1 duplex communication outlet is recommended for each room no matter what the use of the room.

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **SECTION II**

#### **CABLE AND WIRE FACILITIES** (see exhibits A-E)

##### **GENERAL**

1. Cable facilities (conduit, cable trays, raceways etc.) are required for connecting laboratory, classroom, and office pod areas with building communications equipment rooms (IDFs and MDFs). Cable facilities are furnished by project funding.
2. OCIO should be consulted before removal of telephone wire and equipment, i.e., when office partitions are relocated. All wiring must be removed all the way back to the source.
3. All communication outlets will have conduit, Wiremold, or other suitable path provided to the nearest IDF/MDF or to a cable tray that provides a path back to the nearest IDF/MDF.
4. The electrical contractor will provide a pull string in all empty conduits.
5. All work specified shall be UL listed and in accordance with the most current versions of the following codes and agencies:
  - A. The National Electrical Code, Article 800
  - B. National Fire Alarm and Signaling Code (N.F.P.A. 72)
  - C. Life Safety Code (N.F.P.A. 101)
  - D. National Electronic Manufacturer's Association (NEMA)
  - E. Institute of Electronic and Electrical Engineers (IEEE)
  - F. EIA/TIA 568, Commercial Building Telecommunications Wiring Standard which includes EIA/TIA 568A, 569, 607, and TSB 75.

##### **Electrical Facility Relationships**

Although the electrical load is minimal (most devices draw less than 1 amp), every component requires electrical service: modems, terminals, printer, etc. Each communication outlet should be in proximity to a duplex electric outlet in addition to present design requirements to accommodate the need to "plug in" electronic equipment. The Architect/Engineer shall work with the using agency to determine the power requirements of electronic equipment and to provide dedicated circuits where required.

##### **BUILDING CONDUIT AND CABLE TRAY SYSTEMS**

1. Conduits to communication outlets are to be a minimum of one inch. A dedicated conduit will serve each outlet box. All conduit "stubs" must have conduit grounding bushings on the ends and be properly grounded. Pull boxes, if needed, must be accessible. Do not place pull boxes above fixed ceilings, HVAC ducts or piping.
2. No conduit run, without a pull box, is to be longer than 100 feet and no more than two 90-degree bends. No conduit run shall accumulate more than a total of 180 degrees in bends. No conduit Body LB style may be used in lieu of pull boxes for communications. Conduits at time of Life Safety Inspection will be no more than 40% full. See D rating chart. (see Exhibit E).
3. Communication outlet boxes will be H-4 11/16" X W-4 11/16" X D-2 1/8", equipped with a 2-gang cover/plaster ring. Wall-phone outlets will be equipped with a single-gang cover/plaster ring. The height of these boxes will be determined by the use of the box, keeping in mind that wheelchair access heights vary from project to project and close contact with OCIO will eliminate moving the box.
4. A cable wire tray may be placed above drop ceilings with the 1-inch communication outlet conduits stubbed to the cable tray from individual room outlets. This tray will provide a path back to the IDF or MDF. The tray will have a maximum of 8-inch spacing between cable supports and 4-inch sides. Width of the tray will be determined by the quantity of cables in the tray, and projected growth. Cable Trays and conduits must be properly grounded. All NEC codes for grounding of cable trays will be adhered to. Basket Tray is now acceptable, as long as, it has 4 inch sides.

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

5. Access to the IDF or MDF is acceptable by either extending the cable tray or providing conduit.

6. A path from the MDF to IDF(s) and IDF to IDF is required. Cable tray, conduit(s), or sleeved holes (which must be grounded at both ends) that provide this path are acceptable. The volume of cable and predicted expansion determines the size and quantity of the units that make up the path. (See Exhibit A)

7. Approved UL fire stop must be used when penetrating fire rated walls or floors. If conduits are to be fire stopped pliable putty must be used. Several fire stop materials are available as putty. Most have intumescent properties.

These types of putty:

- A. Have the consistency of glazing putty.
- B. Remain permanently soft and pliable.
- C. Allow easy fire stop reentry.
- D. May be installed in conjunction with ceramic fiber, mineral wool filler, or other approved fill material as required.
- E. Hilti CP 618 is strongly recommended or OCIO approved equal.

### EXAMINATION

1. Verify proposed routes of pathways. Check raceways, cable trays, and other elements for compliance with space allocations, clearances, installation tolerances, hazards to cable installation, and other conditions affecting installation. Verify that cabling can be installed complying with EMI clearance requirements.
2. Prepare wall penetrations and verify that penetrations of rated walls are made using products labeled for type of wall penetrated.
3. Identify plan to support cables and raceways in suspended ceilings. Verify weight of individual type and sizes of cables. Verify that load capacity of cable support structures is adequate for each pathway.
4. Proceed with installation only after unsatisfactory conditions have been corrected.

**ELEVATOR PHONES:** The following are the procedures for elevator phones.

1. It should be written into the contract documents that the Electrical Contractor is responsible for the installation costs of the elevator phone line(s).
2. The Electrical Contractor shall send OCIO a letter requesting service be activated to the specific elevator equipment room(s). Indicating the date of service is also required. NOTE: Normal installation time for OCIO is 5 working days from the date of receipt of the request.
3. Facilities Operation and Development shall send OCIO a requisition form E-Request requesting that monthly service fees for the elevator phone lines at the specific location be charged to them on the account number provided.
4. The FOD Design and Construction Project Manager will solicit the above documents from the Electrical Contractor and Facilities Operation and Development, attach them together and forward them to OCIO.
5. See Exhibit R for equipment room layout.

### SECTION III

#### MAIN AND INTERMEDIATE DISTRIBUTION FRAMES

##### GENERAL

OCIO personnel should be consulted during the planning stages of any building construction or building renovation. In some cases, existing MDFs and IDF's may have to be enlarged to accommodate changes in the use of building space. In such cases the project will pay for the enlargement of the facilities.

##### MAIN DISTRIBUTION FRAME (See Exhibit F)

1. Space for connection of the building communication cable to the outside plant should be provided in a separate room and not shared with other utility services, particularly the electrical service. When possible, this room will not be adjacent to the electrical distribution room.
2. Room size will be determined by the size and use of the building. Room size should be large enough to mount electronic equipment to support Local Area Networks (LANs) such as relay racks, hubs, multiport repeaters, or paging. For major renovations and new building projects, a size may or may not be included in the Project Program of Requirements. In either event the project Architect/Engineer must, during the initial (Schematic, Preliminary) planning stage, engage the coordinated efforts of OCIO Telecommunication and Networking, Office of Facilities Planning and Development, and the using agency to ensure appropriate size and arrangement of the communications equipment room(s). These room(s) will need to be environmentally controlled to insure proper reliability of sensitive electronic equipment.
3. Backboards for MDFs and IDF's are to be 3/4"x48"x96" type APA A-D Group 1 plywood, fire retardant treated, with the A side facing the room. All usable walls of MDF/IDF's will have backboards.
4. At all MDF locations a double duplex electric outlet will be **provided on a dedicated circuit, placement of these circuits shall be discussed during the design phase.** A 48-inch double tube fluorescent light should be placed above the MDF/IDF panel. Incandescent lights may be used as long as 50 foot- candle lighting can be obtained at the MDF/IDF panel.
5. A "ring run" will be provided at all MDFs to keep jumper (crosscut) wire organized. This will be accomplished by the use of 4-inch wide aluminum "D" rings screw-mounted above the top of the 66 blocks. The bottom of the "D" ring will be mounted two inches above and centered over the space between each vertical row of blocks. "D" rings should be open or split to allow placement of crosscut wire.

##### DATA CONNECTIVITY

1. Data connectivity shall be on 19 inch racks which will be located either in a communication closet or a designated area set aside for network systems equipment. Such as, but not limited to, routers, hubs, switches, fiber terminations, patch panels, and shelves. (see Exhibit M).
2. Open style data racks shall be 19 inches wide, 84 inches high, and shall meet EIA standards. Racks shall be listed to the UL 1863 Standard for Communication Circuit Accessory. Hubbell CS1976 are strongly recommended for university data connectivity.  
***Under no circumstances shall flush mounted or surface mounted phone panels be used for data connectivity.***
3. Any racks that are floor mounted will be provided with tip bars and all additional accessories as required for a complete functional system. Both vertical and horizontal cable management systems must be provided on all relay racks. There must be enough space in the MDF/IDF's to accommodate 31-inch isle-ways. All racks must be grounded to the building ground or bonded to the cable tray system.
4. Provide a multi-outlet AC plug strip. Provide enough outlets to accommodate all electronic devices in the relay rack. The strips shall be mounted on standoff brackets so as to provide 6 inches of separation from the cable



## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

management system. Strips shall be mounted on the rear of the rack. If UPS systems are being used AC power must be evenly distributed between UPS and other source of AC power.

5. Patch panels for relay racks shall be sized to accommodate current project requirements plus 30% growth capacity. Patch panels shall not exceed 4 x 48 port (maximum total of 192 connections) in a relay rack. Recommended Hubbell UDX48E or OCIO approved equal.

6. Enclosed cabinets shall have a rack mount width of 19 inches and an overall height of at least 76 inches. Enclosed cabinets shall have a roof mounted cable fan and cable entry, enclosed cabinets must be at least 32 inches deep to accommodate a rack mounted UPS. Enclosed cabinets shall be firmly secured as to be unmovable. Recommended enclosed cabinet is Rittal Universal PS Networking Cabinet # 9968086.

7. Wall mounted racks shall be 19 inches in width and 48 inches in height. All wall mounted racks will be mounted on ¾ inch" type APA A-D Group 1 plywood, fire retardant treated, with the A side facing the room. (see Exhibit S for Netshelter requirements).

### INTERMEDIATE DISTRIBUTION FRAMES (See Exhibit G)

1. IDFs will be a secure room, closet, or space directly accessible from a hallway, public access space, or within a mechanical room. Janitor's closets and electrical closets are not acceptable as IDF spaces. A duplex electric outlet will be **provided on a dedicated circuit**. A 48-inch double tube fluorescent light should be placed above the IDF panel. Incandescent lights may be used as long as 50 foot candle lighting can be obtained at the IDF panel.

2. In large buildings, more than one IDF per floor may be required. A large building is defined as any building in which the physical layout of a floor would require cable "runs" (IDF/MDF to outlet) in excess of 300 feet (90 meters).

### GROUNDING

A #6 insulated wire will be provided from the building service entrance ground to all MDFs and IDFs terminated on a ground bar. All equipment, cable tray, ladder rack, relay racks, conduits, and conduit sleeves, will have the same ground as MDF/IDFs. The DC resistance from the MDF/IDF to the building earth ground shall not exceed 0.5 ohms on the longest run. (see Exhibit Q).

### SECURITY

Access to all rooms or closets containing voice or data equipment will be through one uniform key system. Facilities Operation and Development has established the NET keys are to be used. All new buildings after 2012 should have card access to MDF/IDF's for security. Any card access to communications closets must include OCIO personnel.

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### SECTION IV

#### CABLE, WIRE and OUTLET INSTALLATION

##### COMMUNICATION OUTLETS (SEE Exhibit L)

A statement shall be included in all specifications on renovation and construction projects, to read as follows; Cable, wire, and outlet installation shall be performed by personnel that have been certified by an organization such as BICSI (Building Industry Consulting Service International) or have at least 5 years' experience in the telecommunication industry.

1. Minimum Requirements for communication outlets, except wall phone outlets, will be duplex, ivory for phone and black for data, flush mount. Jack mounting plates will be designed for installation of interchangeable modules, manufactured by Hubbell, Leviton, or OCIO approved equal. Floor mounted outlets will be coordinated with the architect, user, and OCIO during the planning stages of each project. Approval of any outlets (jacks) on shop drawings must be handled through the FOD Design & Construction Project Manager and OCIO.
2. The top opening of the faceplate mounting will be equipped with an eight (8) pin ivory module, manufactured by Hubbell (catalog # HXJ6TI), Leviton, or OCIO approved equal. The opening in the module will accommodate a standard male telephone plug.
3. The bottom opening of the faceplate mounting will be equipped with an 8 pin, Category 6, black module, manufactured by Hubbell (catalog # HXJ6BK), Leviton, or OCIO approved equal. The 8 pins will be wired in accordance with ISDN, T568A standard.
4. The faceplate will be stainless steel or plastic in accordance with architectural design (Hubbell IFP26TI). The faceplate shall have four or six modular openings designed to accommodate the jacks listed above. Openings without jacks installed, will have blank inserts installed (Hubbell SFBI10). Stainless steel covers (Hubbell SSF206) should be used in auditoriums and classrooms, where frequent use or abuse is more likely.
5. Wall phone outlets will be plastic, ivory, 6-conductor, and designed for modular mounting of wall phones. Suttle SE 630AC6 44. The highest operable part of the telephone shall be 54".
6. Any configurations beyond this minimum standard will be handled on a per project basis.

##### WIRELESS OPTIONS FY15 (see Exhibit K)

There are 3 options for installing Wireless Access Points (WAPs) from the OCIO. All options include the following:

- Survey of space (virtual or site depending on project) & identify AP locations
- Estimate development depending on which option is chosen
- OCIO purchases WAPs & Ethernet switches
- Certification upon completion of installation.
- See Exhibit "K" of the OSU Wiring Standard for installation guidelines.
- For pricing model please contact 614-688-4357 (8-HELP on Campus) and ask for a Relationship Manager.

Option A :

OCIO complete install

- Installation of WAPs including cabling and basic pathway by the OCIO
- If additional pathway is needed it will be included in the estimate to the customer
- Full price/no credits

Option B:

Project supplies pathway and cable with terminations, OCIO installs WAPs

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

- Installation of pathway and cabling by project for WAPs
- Project is responsible for all terminations and testing
- OCIO will inspect installation and witness testing of cabling
- Prior to placement of WAPs a mock-up will be provided for OCIO approval.
- OCIO will install WAPs upon completion of testing
- With this option there will be a credit given for each WAP since the project installed the pathway/cabling
- Removal and storage of WAPs will be done by the OCIO on renovation projects. Project Managers are to notify the OCIO when WAPs can be removed.

### Option C:

Project is responsible for pathway/cabling/terminations/WAP installation

- Installation of pathway and cabling by project for WAPs
- Project is responsible for all terminations and testing
- OCIO will inspect installation and witness testing of cabling
- Prior to placement of WAPs a mock-up will be provided for OCIO approval.
- OCIO provides WAPs for the project to install.
- Project is responsible for placement of WAPs after inspection and testing is complete
- With this option there will be a credit given for each WAP since the project installed the pathway/cabling and WAP
- Removal and storage of WAPs will be done by the OCIO on renovation projects. Project Managers are to notify the OCIO when WAPs can be removed.

## STATION WIRE

1. Each communication faceplate will be wired with a minimum of two 4-pair unshielded (**Category 6**) station wires. Each wall phone outlet will be wired with one 4 pair unshielded (**Category 6**) station wire. All station wire will be 24-gauge, twisted, solid annealed copper conductor, individually insulated with high density color-coded PVC. All communication wire and cable installed in a building must meet the requirements of ARTICLE 800 of the National Electrical Code. Splicing in station wire is not permitted; wire must be continuous from IDF or MDF to the outlet (jack). (I.e. extending of communications and/or data outlets is not permitted). Wireless access points will be a Category 6 station wire. (see Exhibit K).

A. Any cabling that is kinked, stretched, punctured, ripped, or twisted will be removed and reinstalled at contractors cost.

B. No low voltage cabling will touch ceiling tile, ceiling grids, conduits, walls, or any other structure. Cable will only rest in the pathway that it was designed to be installed in.

2. One of the 4 pair (**Category 6**) station wires will be terminated on the top module of the faceplate in accordance with the color-coding on the module, and punched down on the blocks at the IDF/MDF.

3. One of the 4 pair (**Category 6**) station wires will be terminated on the bottom module of the faceplate in accordance with the color coding on the module. **CAUTION: Very close attention must be paid in maintaining the twist of the pairs at both ends of the cable! The twist must be within 1/2 inch of any termination.**

4. Each communication faceplate will be numbered as follows with a 4-digit number: Each faceplate must have numbers for every outlet on that faceplate. The first digit of the number will be the floor. That is, 0 will be used for ground floor or basement, 1 will be the first floor, and 2 will be the second floor, continuing through the appropriate number. The next three digits will be sequential numbers starting with 001 if there is only one IDF on a floor. If the building has more than one IDF on a floor, each IDF will have a block of 250 numbers assigned to it. That is, 001 through 250 for IDF number 1, 251 through 500 for IDF number 2, and so on, as required.

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

5. The numbering of the blocks in the MDF or IDF's must be sequential numbers starting at the top left of the block and continuing straight down the block or row of blocks. All voice jacks will have odd numbers only, example (001, 003, 005, etc.) All data jacks will have even numbers only example (002, 004, 006, etc.) In MDF/IDF locations on renovation projects where the numbering is already established check with OCIO on the next sequential number to be used.

6. After each communication outlet is wired and the IDF is punched down, every conductor must be checked for shorts, crosses, reversals, and continuity. Cat 6 data jacks should also be checked for attenuation, capacitance, impedance, resistance, near-end cross talk, cable length, ELFEXT, return loss delay, delay skew, and ambient noise. Tests shall follow TIA-568-C specifications and be witnessed by a Representative of OCIO and shall be monitored by a recorder where appropriate. Fluke Networks DSX 5000 or OCIO approved equal. Provide a hard copy of test results to OCIO, or a disk with the test results in Microsoft word format.

### COLOR CODES:

- Pair 1 - White Blue, Blue White
- Pair 2 - White Orange, Orange White
- Pair 3 - White Green, Green White
- Pair 4 - White Brown, Brown White

**MDF/IDF;** Beginning in July of 2010 all new buildings with no existing MDF/IDF will be utilizing 110 wiring blocks instead of 66 blocks (See Exhibits O & P). Terminations will be on 110 style blocks with a 300 pair base.

- 1) Shall utilize Industry normal footprint.
- 2) Must have labeling areas on front and label kits.
- 3) Fully Compliant ANSI/TIA/EIA 568A Category 6.
- 4) 110 style IDC termination system.
- 5) All blocks will be mounted on stand-off legs.
- 6) Enough connecting blocks must be provided to match all pairs of wiring block.
- 7) Ortronics OR-110ABC6300 for station cables or OCIO approved equal.
- 8) Hubbell 110 BLK 300 FTK5 for Riser cables or OCIO approved equal.
- 9) All feeder cables and station cables will be fed from as far left as possible on the wall and from across the bottom of the plywood and up through the bottom of the blocks.

### IDs (See Exhibit G)

1. At the IDF, 66M150 type blocks are to be used with an 89B standoff bracket for the riser cable and the telephone station wire. Separate blocks or rows of blocks will be used for riser cables and for telephone wire terminations. Relay racks may be used for 4 pair Data cable terminations. Riser cable blocks will be mounted to the left, station wire blocks will be mounted to the right at the IDF. The 4 pair Data cabling may be mounted on relay racks. Patch panels are to have 48 ports, and use a standard 8 pin module for data cabling. **CAUTION: Very close attention must be paid in maintaining the twist of the pairs on patch panels. The twist must be within 1/2 inch of the termination.**
2. Terminate the riser cable following the standard telephony color code (see Exhibit H) using the first row of pins on the left and the last row of pins on the right of the block. The riser cable will be fed up through the bottom of the 66 block standoff brackets. **CAUTION: Very close attention must be paid in maintaining the twist of the pairs in all riser cables. The twist must be within 1/2 inch of the termination.**
3. The 4 pair station wire will be punched down using the first row of pins on the left and the last row of pins on the right of the 66M150 blocks and identified by a jack number. Station wire will be fed through the bottom of the 66 block standoff brackets. **CAUTION: Very close attention must be paid in maintaining the twist of the pairs in all station cables. The twist must be within 1/2 inch of any termination.**
4. The size of the IDF will determine how the 66 blocks and exhibit are to be arranged. The 66 blocks are to be stacked no more than four blocks high with a 2-inch space between the rows of blocks. The Relay Racks are to be arranged to allow at least 31 inches of clearance on three sides of the rack.

### MDF (See Exhibit F)

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

1. All punch down blocks are to start from left to right. Space is to be reserved at the far left for the underground cable and the protectors to be mounted and terminated. The underground cable and protectors will be installed and punched down by OCIO Telecommunication and Networking.
2. The riser cables' 66M150 blocks will be stacked no more than four high. The top of the 66M150 blocks are to be no more than 72 inches from the floor and the bottom of the lowest block shall be no lower than 30 inches from the floor.
3. All cables and station wire will be fed from the bottom of the 66M150 blocks through the 89B brackets and terminated. The standard telephony color code is to be followed.
4. The first row of riser cable blocks would be the ground floor or basement IDF riser cable. The next row would be the first floor riser cable, and so on throughout the building.
5. If station wires are installed at the MDF, they will be terminated on 66M150 blocks, to the right side of the riser cables. The 4 pair station wire for telephones will be terminated immediately to the right of the riser cable.
- 6 All the blocks are to be mounted with a 2-inch space between each row. This allows room for crosscuts to be run.

### **RISER CABLE (EXHIBIT I)**

1. Riser cables will be 24 gauge, Category 3, twisted solid annealed copper conductors, individually insulated and color coded in accordance with telephone industry standards. Cables having more than 25 pairs will be assembled in individual color-coded binders. All communications wire or cable installed in a building must meet requirements of Article 800 of the National Electrical Code.
2. The riser cable will be sized by the number of communication outlets plus 30%, rounding off the riser cable to the nearest standard size. Minimum size is 100 pairs.
3. In addition to the multi-pair copper riser cables, a minimum of 1 six strand multi-mode, 1 six strand single mode fiber cable (riser rated) or plenum rated when necessary, and one Category 6 unshielded twisted pair cable for each 23 data cables (never to exceed 100 meters), will be run from the MDF to each IDF. The path for these cables will be directly from the MDF to each IDF. Both the fiber and the data cables will be terminated in relay racks.

### **SPLICING DEVICES**

During renovation projects where an MDF or IDF is being created or relocated splicing the riser cables shall be reviewed by OCIO. Upon approval splicing may be permitted in the copper riser cables only. Modular splicing devices that are to be used must also be approved.

### **SPLICE CASES**

An approved cover for splices in a riser system must be used where any two or more cables are spliced together.

### **PUNCH DOWN BLOCKS**

66M150 type blocks are to be used with an 89 B standoff brackets at both MDF and IDFs to terminate the riser cables and the station wires. Starting in July of 2010 110 blocks will be utilized on all new buildings. The only 110 blocks authorized for use is Ortronics OR110ABC6300 for station cables and Hubbell 110 BLK 300 FTK 5 for Riser cables or OCIO approved equal

### **CATV- Cable TV Overview**

Office of the CIO will have first opportunity to design the cable TV distribution. If it's agreed upon that the contractor will provide the cable TV design, Office of the CIO will have the opportunity to review and approve the contractor's design.

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

Contractor will only use hardware that's been provided in the OCIO approved materials list for CATV. If the contractor desires to use hardware other than what's been identified as approved, said contractor will be required to submit samples of the alternate hardware and why the alternate hardware is being requested.

Contractor will be required to place CATV cable drops and hardline distribution to Office of the CIO standards. If Office of the CIO is requested to install any/all wiring it will be at standard Office of the CIO hourly rates and will be billed to the construction project.

Office of the CIO will have first opportunity to perform splicing, activation, testing and documentation of building distribution and CATV cable drop wiring. This will ensure that those aspects are completed to Office of the CIO standards. Assigned contractor shall subcontract OCIO for design, splicing and terminations.

Should Office of the CIO find damaged CATV cable drops and/or hardline coax, Office of the CIO will notify the contractor. Contractor will have first opportunity to replace damaged coax at contractor's expense. Should contractor not be able to replace damaged coax in a timely manner, Office of the CIO will have the coax replaced and bill the construction project.

### CABLE TV. CABLING

1. All cable TV. runs will be routed directly from the IDF to the outlet. Splitters and Amplifiers will be mounted at the IDF.

2. The connectors will be a "F" type. Compression type fittings are the only acceptable "F" connectors to be used. **CAUTION: Proper tools must be used to install the "F" connectors to insure the proper fit and also to insure there is no RF signal leakage. OCIO recommends the Ripley Cablematic C.A.T "All Series" Compression Assembly Tool.** The CATV outlet shall be a 75 ohm female "F" to female "F" wall plate adaptor or be IPTV type.

3. For runs of less than 200 feet, drop cable shall be 6 Series quad-shield 75 ohm coaxial cable. The core shall be 18-gauge copper covered steel center conductor with a gas expanded polyethylene dielectric. The shield shall be aluminum-polypropylene-aluminum laminated tape with overlap bonded to dielectric, a 60% braid of 34 AWG bare aluminum wire, an aluminum-polypropylene-aluminum laminated tape, and a 42% braid of 34 AWG bare aluminum wire. The jacket shall be made of flame retardant polyvinyl chloride. The Series 6 drop cable shall be Commscope #5781 (Plenum #2227V) or OCIO approved equivalent. The connector for the Series 6 drop cable shall be Gilbert #GF-URS-6 (Plenum GF UR 6 PL) or OCIO approved equal.

4. For runs of 201-350 feet in length drop cable shall be 11 Series quad-shield 75 ohm coaxial cable. Any run exceeding 350 feet in length, OCIO must be contacted for technical consultation. The core shall be 14-gauge copper covered steel center conductor with a gas expanded polyethylene dielectric. The shield shall be aluminum-polypropylene-aluminum laminated tape with overlap bonded to dielectric, a 60% braid of 34 AWG bare aluminum wire, an aluminum-polypropylene-aluminum laminated tape, and a 40% braid of 34 AWG bare aluminum wire. The jacket shall be made of flame retardant polyvinyl chloride. The Series 11 drop cable shall be Commscope #5940 (Plenum #2287K) or OCIO approved equivalent. The connector for the Series 11 drop cable shall be Gilbert #GAF-URS-11-MH (Plenum GAF-UR-11 PL) or OCIO approved equal.

5. Riser cable for RF distribution shall be 0.500" aluminum sheathed 75 ohm distribution cable. The core shall have a fully bonded copper clad center conductor with a high compression, micro cellular foam dielectric. The outer tube shall be solid aluminum. The riser cable shall be Commscope #P3 500 CA or OCIO approved equivalent. The connector shall be GRS-500-CH-DU-03-T or OCIO approved equal

### FIBER OPTIC RISER CABLE

Each IDF will have at least 6 strands of armored (all dielectric) 50 micron laser optimized cable (OM3) terminated with fusion spliced LC style pigtailed and 6 strands of armored (all dielectric) singlemode cable terminated with pre-terminated SC/APC pigtailed placed to the building MDF. All singlemode cable will be fusion

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

spliced (or ordered factory preterm). No field connectors will be allowed, nor any mechanical splicing of singlemode tails. All terminations will be housed in fiber optic patch panels in the rack. There will be a 20' service loop at each TR. The 20' service loop will be placed on the wall using Leviton 49800- 0FR for slack management (see Exhibit A) in a craftsmanship like manner. Slack inside the fiber housings does not count towards the 20' service loop. All cable, hardware, and connectors will be of one manufacturer. There will be at a minimum two (2) 3 meter duplex (LC/LC) multimode jumpers and two (2) 3 meter duplex (SC-APC/LC) singlemode jumpers provided by the project for every six (6) strands of fiber. The jumpers will be of the same manufacture as the cable and hardware components. University Preferred selection; CCH housings and CCH splice cassettes.

### **Specification for Fiber Optic Cables**

#### **Single-mode Optical Fiber in Tight Buffer Cables**

The single-mode Low Water Peak fiber utilized in the optical fiber cable shall meet EIA/TIA-492CAAB, "Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak," and ITU recommendation G.652.D, "Characteristics of a single-mode optical fiber cable."

A Germania-doped silica core surrounded by a concentric silica glass cladding shall comprise each optical fiber. The fiber shall be a matched clad design manufactured by the outside vapor deposition process (OVD). Each optical fiber refractive index profile shall be step index.

The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.

#### **Geometry**

- 2.1 Cladding Diameter ( $\mu\text{m}$ )  $125.0 \pm 0.7$
- 2.2 Core-to-Cladding Concentricity ( $\mu\text{m}$ )  $\leq 0.5$
- 2.3 Cladding Non-Circularity  $\leq 0.7 \%$
- 2.4 Mode Field Diameter ( $\mu\text{m}$ )  
1550 nm  
 $10.4 \pm 0.5$
- 2.5 Coating Diameter ( $\mu\text{m}$ )  $245 \pm 5$
- 2.6 Colored Fiber Nominal Diameter ( $\mu\text{m}$ ) 253 - 259
- 2.7 Fiber Curl radius of curvature (m)  $> 4.0$  m
- 2.8  
Cabled Fiber Attenuation (dB/km)  
1310 nm  $\leq 1.0$   
 $1383 \pm 3$  nm  $\leq 1.0$   
1550 nm  $\leq 0.75$

#### **Multimode Optical Fiber in Tight Buffer Cables**

Industry-standard multimode fiber supports 10 Gb/s serial transmission for a guaranteed distance of 300 m using 850 nm VCSEL sources. Fiber supports current network requirements from 10 Mb/s to 622 Mb/s using LED-based protocols and enables cost-effective migration to laser-based protocols such as 10 Gigabit Ethernet, Gigabit Ethernet and 10 Gigabit Fiber Channel (10GFC). Bandwidth-intensive applications and congested backbone links requiring scalability are cost-effectively supported through premises intrabuilding and intrabuilding optical fiber cable plant including local area networks (LANs), storage area networks (SANs) and data centers.

Each fiber in the cable must be usable and meet required specifications. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical and environmental requirements of this specification. A Germania-doped silica core surrounded by a concentric silica glass cladding shall comprise each optical fiber. The fiber shall be a matched clad design manufactured by the outside vapor deposition process (OVD). Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

GN/m<sup>2</sup>). The fiber shall be coated with a dual-layer acrylate protective coating. The coating shall be in physical contact with the cladding surface. The attenuation specification shall be a maximum value for each cabled fiber at  $23 \pm 5^{\circ}\text{C}$  on the original shipping reel. The multimode fiber shall meet TIA-492AAAC, "Detail Specification for 850-nm Laser-Optimized, 50- $\mu\text{m}$  Core Diameter/125- $\mu\text{m}$  Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers."

The core diameter shall be  $50.0 \pm 2.5 \mu\text{m}$ . The cladding diameter shall be  $125.0 \pm 2.0 \mu\text{m}$ . The cladding non-circularity shall be  $= 1.0\%$ . The core-clad concentricity shall be  $= 1.5 \mu\text{m}$ . The coating diameter shall be  $245 \pm 5 \mu\text{m}$ . The optical fiber refractive index profile shall be graded. The numerical aperture of the fiber shall be  $0.200 \pm 0.015$ .

The maximum cabled fiber attenuation shall be 3.0 dB/km at 850 nm and 1.5 dB/km at 1300 nm for all cable types. The cabled optical fiber shall have a minimum effective modal bandwidth (EMB) of 2000 MHz•km at 850 nm in accordance with FOTP-220 for 10 Gigabit Ethernet. The cabled optical fiber shall have a minimum over-filled launch (OFL) bandwidth of 1500/500 MHz•km at 850/1300 nm. The cabled optical fiber shall have a minimum restricted mode launch (RML) bandwidth of 1400 MHz•km at 850 nm in accordance with FOTP-204 for Gigabit Ethernet.

The cabled optical fiber shall support industry-standard IEEE 802.3 10GBASE-S (10 Gigabit Ethernet at 850 nm) physical layer specifications for 300 m. The cabled optical fiber shall support industry-standard IEEE 802.3 1000BASE-SX (Gigabit Ethernet at 850 nm) physical layer specifications for 1000 m and 1000BASE-LX (Gigabit Ethernet at 1300 nm) for 600 m. The cabled optical fiber shall support industry-standard multi-gigabit Fiber Channel physical interface specifications.

There shall be no point discontinuity greater than 0.2 dB. The attenuation coefficient at 1380 nm shall not exceed the attenuation coefficient at 1300 nm by more than 3.0 dB/km. The attenuation due to 100 turns of fiber around a 75 mm diameter mandrel shall not exceed 0.5 dB at 850 nm and 1300 nm.

### Riser Rated Distribution Interlocking Armored Cable, 2-24 Fibers

Cable shall be riser-rated with 2 to 24  $900 \pm 50 \mu\text{m}$  tight-buffered fibers. TBII® Tight-Buffered Fiber shall be made of a PVC material and shall have a UV-cured acrylate coating (low-friction slip layer) between the acrylate coating of the optical fiber and the PVC buffer. The fiber coating, low friction slip layer and PVC buffer shall be removable with commercially available stripping tools in a single pass for termination or splicing. The individual fibers shall be color-coded for identification. The optical fiber color coding shall be in accordance with TIA/EIA-598-B, "Optical Fiber Cable Color Coding." Fibers shall be stranded together around dielectric strength members or a glass reinforced plastic (GRP) via reverse oscillation and surrounded with dielectric strength members. Cables containing 12 to 24 fibers shall have a dual-layer stranded design. Cable shall contain a ripcord underneath cable jacket to facilitate jacket removal. The cable jacket color shall be orange for cables containing all multimode fiber, except for cables containing 50/125  $\mu\text{m}$ , 850 nm laser optimized fiber, which shall have an aqua colored outer jacket. The cable jacket color shall be yellow for cables containing all single mode fiber. Hybrid cables (containing more than one type of fiber) shall have an outer jacket with the color corresponding to the greatest percentage of total fibers within the cable, except for hybrid cables containing 50/125  $\mu\text{m}$ , 850 nm laser optimized fiber, which shall have an aqua colored outer jacket. Unique color identification of all fibers within the hybrid cable shall correspond to fiber core diameter (or mode field diameter) from smallest to largest in accordance with TIA/EIA-598-B. A spirally wrapped interlocking aluminum tape (interlocking armor) shall encase the cable. The cable with interlocking armor shall be available with an additional outer flame-retardant jacket. The color of the outer jacket shall match the jacket color of the optical fiber cable located underneath the armor. The interlocking armor for these cables shall be comparable to liquid tight flexible metal conduit if jacketed, or flexible metal conduit if not. Cables with a flame-retardant jacket over interlocking armor shall be marked with the manufacturer's name, date of manufacture, fiber count, fiber type, flame rating, listing symbol, and sequential length markings every 2'. The marking shall be in contrasting color to the cable jacket. Cables without a flame-retardant outer jacket shall not be marked on the interlocking armor.

Cable shall have a storage temperature range of  $-40^{\circ}$  to  $+70^{\circ}\text{C}$ , installation temperature range of  $-10^{\circ}$  to  $+60^{\circ}\text{C}$ , and an operating temperature range of  $-20^{\circ}$  to  $+70^{\circ}\text{C}$ . Cable shall be listed OFCR/FT-4 and be fully compliant with ICEA S-83-596. Cable manufacturer shall be ISO 9001 registered. Cable manufacturer shall have a minimum of 20 years in manufacturing optical fiber cable in order to demonstrate reliable field performance.



## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

Cable and fiber manufacturer shall be the same company to ensure long-term reliability of the cabled fiber and to ensure the availability of fully integrated technical support.

**University Preferred Selection:** Corning Cable Systems part number 006E81-31131-A1 for single-mode, and 006T81-31180-A1 for 50 micron multimode LOMMF.

### **Plenum Rated Distribution Interlocking Armored Cable, 2-24 Fibers**

Cable shall be plenum-rated with two to twenty-four  $900 \pm 50 \mu\text{m}$  tight-buffered fibers. TBII® Tight-Buffered Fiber shall be made of a PVC material and shall have a UV-cured acrylate coating (low-friction slip layer) between the acrylate coating of the optical fiber and the PVC buffer. The fiber coating, low friction slip layer and PVC buffer shall be removable with commercially available stripping tools in a single pass for termination or splicing. The individual fibers shall be color-coded for identification. The optical fiber color coding shall be in accordance with TIA/EIA-598-B, "Optical Fiber Cable Color Coding." Fibers shall be stranded together around jacketed or non-jacketed dielectric strength members via reverse oscillation and surrounded with dielectric strength members. Cables containing 12 to 24 fibers shall have a dual-layer stranded design. Cable shall contain a ripcord underneath cable jacket to facilitate jacket removal. The cable jacket color shall be orange for cables containing all multimode fiber, except for cables containing 50/125  $\mu\text{m}$ , 850 nm laser optimized fiber, which shall have an aqua colored outer jacket. The cable jacket color shall be yellow for cables containing all single mode fiber. Hybrid cables (containing more than one type of fiber) shall have an outer jacket with the color corresponding to the greatest percentage of total fibers within the cable, except for hybrid cables containing 50/125  $\mu\text{m}$ , 850 nm laser optimized fiber, which shall have an aqua colored outer jacket. Unique color identification of all fibers within the hybrid cable shall correspond to fiber core diameter (or mode field diameter) from smallest to largest in accordance with TIA/EIA-598-B. A spirally wrapped interlocking aluminum tape (interlocking armor) shall encase the cable. The cable with interlocking armor shall be available with an additional outer flame-retardant jacket. The color of the outer jacket shall match the jacket color of the optical fiber cable located underneath the armor. The interlocking armor for these cables shall be comparable to liquid tight flexible metal conduit if jacketed, or flexible metal conduit if not. Cables with a flame-retardant jacket over interlocking armor shall be marked with the manufacturer's name, date of manufacture, fiber count, fiber type, flame rating, listing symbol, and sequential length markings every 2' (e.g., "MANUFACTURER NAME - 01/00 - 12 SM - TB2 - OFCP (ETL) OFC FT6 (CSA)0001 FEET"). The marking shall be in contrasting color to the cable jacket. Cables without a flame-retardant outer jacket shall not be marked on the interlocking armor.

Cable shall have a storage temperature range of  $-40^{\circ}$  to  $+70^{\circ}\text{C}$ , installation temperature range of  $0^{\circ}$  to  $+60^{\circ}\text{C}$ , and an operating temperature range of  $0^{\circ}$  to  $+70^{\circ}\text{C}$ . Cable shall be listed OFCP/FT6 and be fully compliant with ICEA S-83-596. Cable manufacturer shall be ISO 9001 registered. Cable manufacturer shall have a minimum of 10 years in manufacturing optical fiber cable in order to demonstrate reliable field performance. Cable and fiber manufacturer shall be the same company to ensure long-term reliability of the cabled fiber and to ensure the availability of fully integrated technical support.

**University Preferred Selection:** Corning Cable Systems part number 006E88-31131-A3 for single-mode and 006T88-31180-A3 for multimode 50 micron multimode LOMMF.

## FIBER OPTIC HARDWARE

### **Rack-Mountable Hardware - 3U Rack Space**

Primary Application: Used when both patch panel and splice storage is needed, such as during pigtail splicing.

Housings shall be mountable in an EIA-310 compatible 465 or 592 mm rack and shall be 3 rack units in height as specified by the systems design. Manufacturer shall be ISO 9001 and TL 9000 registered. One EIA rack space or panel height (denoted as 1U) is defined as being 44.45 mm in height. The unit shall be modular with a splicing compartment and a termination compartment in a single housing. The unit shall meet the design requirements of ANSI/TIA/EIA-568 and the polymer compounds flammability requirements of UL 94 V-0. Housings shall be manufactured using 16-gauge aluminum or equivalent for structural integrity and shall be finished with a wrinkled black powder coat for durability. Assembly hardware and equipment-attaching-machine screws shall be included and shall be black in color. The unit shall have patch cord routing guides that allow a transition and segregation point for jumpers exiting the sides of the housing. The unit shall have an open top panel that allows jumper routing through the top of the housing. This shall interface with a separate jumper

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

management panel to ease administration and access in higher-density applications. An optional cover shall be available to close off this open top if jumper routing out the top of the housing is not desired. The 3U housing shall hold four patch panels.

Splice capacity for the 3U housing shall be four 0.2" splice trays or two 0.4" splice trays. Either unit shall include a clamshell-type cable clamping mechanism to provide cable strain-relief. The front and rear doors shall be lockable when used with an optional key lock kit. The housings shall have a labeling scheme that complies with ANSI/TIA/EIA-606. The Connector Housings shall be available with factory-installed connectorized cable stubs in multiple cable and connector types. Brackets shall be available that allow wall mounting of the Rack-Mount Hardware.

**University Preferred Selection:** Closet Connector Housing (CCH) shall be Corning Cable Systems part number CCH-02U & 03U or for 2- and 3-rack-unit-high housings respectively.

### FIBER OPTIC CONNECTOR PANELS

Primary Application: The panels are used with field-installable connectors or in applications where the preconnectorized cables are routed directly from the equipment to the piece of interconnect hardware.

The fiber optic connector panels shall be offered in 6-, and 12-fiber versions. The panels shall be able to be used with field-installable connectors or in applications where the preconnectorized cables are routed directly from the equipment to the interconnect hardware. The 6-fiber panels shall be offered in ST® compatible, FC, SC simplex. The 12-fiber versions shall include ST Compatible Connector, FC, LC duplex, and the SC duplex.

The fiber optic connector panels shall be designed to accommodate applications requiring specified labeling and connector identification. This shall be accomplished by the use of colored snap-in icons with different symbols molded into the icon. The colored icons shall be offered in a variety of colors. As a minimum, these icons shall be available with the following symbols: computer terminals (for fiber-to-the-desktop), telephones, video cameras, CATV, satellite dish or CAT 5e. The icons shall also be available in a variety of colors, including blue, yellow, red, white, electric ivory, ash, green, purple, gray, black, brown and orange. All the icons and colors shall be compliant with the TIA/EIA-606 labeling standard. Panels that accept icons shall come standard with the "blank red" icon. Rack- and Wall-Mountable Connector Housings shall accept an interchangeable connector panel.

The panel shall be attached with two push-pull latches to allow quick installation and removal. Blank connector panels shall be available to fill unused space within the housings. The blank connector panel shall be attached with at least two push-pull latches to allow quick installation and removal. The blank panels shall be manufactured from injection-molded polycarbonate. Panels shall be manufactured from 16-gauge cold rolled steel or injection-molded polycarbonate for structural integrity.

**University Preferred Selection:** Corning LC compatible multimode 50 micron LOMMF shall be CCH-CP06-E4. Corning SC/APC compatible single mode 8.3 micron shall be CCH-CP06-6C.

### FIBER OPTIC PRETERM SPLICING

Splicing of preterm tails will take place in approved termination housings using splicing cassettes. Add connector panels to cassettes as needed.

University Preferred Selection; Corning Cable Systems CCH-CS.

### PRETERM FIBER OPTIC TAILS

All preterm fiber optic tails will be fusion splice method for both multimode and single mode applications; at no time will mechanical splicing be acceptable. Preterm tails for multimode will be duplex LC connectors. Preterm tails for single mode will be simplex SC/APC connectors.

University Preferred Selection; Corning Cable Systems 050006s8180003M for multimode.  
University Preferred Selection; Corning Cable Systems 440006R8131003M for single mode.

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### FIBER OPTIC TESTING PROCEDURES

1. OCIO will be notified one week in advance of testing to arrange personnel to be present during testing.
2. Riser cables will be tested with light source and power meter with only one strand being tested at a time. There are to be no "combo" units allowed (Cat 6 tester and a fiber tester in one unit). Fiber will be tested at 850 nm and 1300 nm for multimode cable, 1310 nm and 1550 nm for singlemode cable. Factory calibration must be current for the fiber optic testers, factory documentation must be provided in submittals.
3. Each strand will be tested and electronically stored. Once testing is complete results will be downloaded and turned over to the OCIO Electronically with manufacturer viewing software accompanying results.
4. Multimode testing will be performed using TIA/EIA-526-14-B Method B for in building riser cables Encircled Flux testing is a requirement, proper mandrels must be used.
5. Single mode testing will be performed using TIA.EIA-526-7 Method A.1 for in building riser cables. For outside plant cables TIA/EIA-52607 Method A.1 and Method B will be used. If issues arise in the building riser cables it will be the responsibility of the contractor to supply an OTDR for further testing and trouble shooting.

All Fiber Optic cables shall be run from the MDF to each IDF. The only allowable splicing is within the fiber termination housing for the pre-terminated tails. **All Fiber Optic Cable inside of buildings will be run in innerducts or be Armored for protection.** These innerducts will be placed in cable trays, in riser sleeves, or any conduits that share fiber and copper. Innerducts will be sized with 50% fill capacity upon initial use. Starting in July of 2010 all new buildings will have Armored fiber only, run from MDF to each IDF.

#### Fiber Optic in Ducts and Conduits:

Provide cable lubricant compatible with the cable sheathing material when pulling cable. Attach pulling fixtures to the cable strength members. When indirect attachments are used, match the grip diameter and length to the cable diameter and characteristics. When indirect attachment is used on cables having only central strength members, reduce pulling forces to ensure that fibers are not damaged from forces being transmitted to the strength member. During pulling of the cable, continuously monitor pull line tension, and shall not exceed maximum tension given by the cable manufacturer. Mechanical stress placed upon the cable during installation shall be such that cable in not twisted or stretched. Provide cable feeder guide between cable reel and face of duct or conduit to protect and guide cable into the duct or conduit as it is played off of the reel. As cable is played off of the reel, carefully inspect the jacket for defects. Take precautions during installation to prevent the cable from being kinked or crushed and that the minimum bend radius is not exceeded at anytime. Hand feed and guide cable through each junction box and apply additional lubricant at intermediate junction boxes. When practicable, use the center pulling technique to lower pulling tension. When the cable is pulled out of a junction box protect from dirt and moisture.

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **Section V THE OHIO STATE UNIVERSITY OUTSIDE PLANT STANDARDS**

The purpose of this document is to provide guidelines for installation of outside plant facilities including building entrances, maintenance holes, conduit, and tunnel entrances.

These guidelines are to be used as a means to provide minimum requirements. Specific requirements for each project will be coordinated with the using agency and an Office of the CIO Telecommunications and Networking outside plant management team during project development.

#### **GENERAL**

Office of the CIO personnel should be consulted during the planning stages of any building construction or building renovation. In some cases, present Entrance Facilities (EF), Main Distribution Frame (MDF), and Intermediate Distribution Frame (IDF) may have to be enlarged or redesigned to accommodate changes in the use of building space.

All cable that is to be connected to or disconnected from the campus communication network must be done by Office of the CIO personnel. The customer must contact Office of the CIO six weeks prior to installation of any new facilities needing placed (if temporary service must be placed it will be done at the cost of the project). Contractors must submit a request on company letterhead for both installation and removals, they can be faxed to 614.688.3425, questions can be directed to 614.688.HELP option 2. The request to connect/disconnect/or move must follow established guidelines. Cabling must be removed back to the source once disconnected (disconnect to be done by Office of the CIO) by the contractor.

Office of the CIO will review drawings and specifications on construction and renovation projects for compliance with the University Outside Plant Standards. Office of the CIO will approve drawings and specifications through the Architects Office.

Prior to ordering of materials selected contractor must turn in submittals 6 weeks in advance for Office of the CIO to approve/disapprove. In addition to all other required copies of submittals, Submit two copies to OCIO through the project manager for review by OCIO.

Any project that requires moving or rerouting of telecommunications and networking cables will bear the cost of said moves.

All pathway work will be paid by project funding.

All materials specified shall be UL listed and in accordance with the most recent versions of the following codes and agencies:

The National Electrical Code  
National Fire Code  
Life Safety Code  
National Electronic Manufactures Association  
Institute of Electronic and Electrical Engineers  
EIA/TIA standards

All as-builts will be turned over to the Office of the CIO Outside Plant Department within 2 weeks of completion. The as-built will contain linear measurements of conduit, and locations of manholes and conduit relative to a visible measuring point. This can be off the face of a building or the back of a curb. These measurements should be two directional. It is understood that GPS can also be used as long as it is tied to the Campus Mapping System.

Office of the CIO designers shall have access to construction sites.

To enable Office of the CIO to inspect telecommunications and networking facilities work, the contractor must:

Provide a progress schedule with the installation of telecommunications and networking raceways and spaces shown as a separate item.

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

Immediately notify Office of the CIO of any change in architectural drawings and/or plans affecting Office of the CIO facilities.

Provide proper access and facilities for inspections.

Notify Office of the CIO when any work is ready for inspection.

All underground work shall be inspected and approved by Office of the CIO through the University Project Manager, before the site is covered. Failure to have the work inspected shall result in uncovering the area at the contractor's expense.

### **1. Outside Plant Pathway and Entrance Facilities**

#### **1.1 INTRODUCTION**

This section provides the necessary guidelines to install service entrances to buildings and information for the termination of cables entering buildings. Topics addressed are voice, data, and video.

Prior to start of work on any project .all outside plant voice, data, video cabling, conduit and manholes shall be designed Office of the Chief Information Officer (OCIO) Outside Plant Department.

All outside pathways for outside plant cabling shall be designed by the A/E and must be reviewed and approved by the OCIO prior to start of any work on a project. Submittals must be turned in for all materials to be used in the outside plant project and approved prior to start of installation.

The project must give 6 weeks' notice for installation of outside plant cables to provide service to the building. If service must be placed as temporary, the project will cover the cost of the temporary installation.

#### **1.2.1 GENERAL**

All cables associated with the campus telecommunications network (telephone, data, LAN, WAN, campus TV, and fiber optics) shall be connected and disconnected by Office of the CIO or its designate.

Office of the CIO will provide main feed cables to each building, including placement and terminations of each cabling medium (voice, data, and video). The Project (building contractor) will be responsible for pathway to new/renovated building from the nearest manhole/tunnel or point of feed designated by Office of the CIO Outside Plant Department. These pathways must meet Office of the CIO standards and meet all NEC codes. These pathways are for only low voltage cables.

#### **1.2.2 AERIAL**

Most university low voltage cabling is underground. No aerial cabling shall be installed on campus unless approved by Office of the CIO and/or the University Architects' Project Manager.

#### **1.3 CONDUIT**

##### **1.3.1 GENERAL**

Conduit sizing and quantities between buildings shall be determined by Office of the CIO and will be communicated to the FOD Design & Construction Project Manager for inclusion in the project specifications. Minimum requirements are outlined in the following paragraphs.

Prior approval and coordination with Office of the CIO, FOD Design & Construction Project Manager, and other concerned parties is necessary when the situation requires any modification to the conduit system.

Repair or replacement of damaged conduit is the responsibility of the party involved in causing the damage. All damages shall be reported to Office of the CIO, Construction Management and Facilities Management immediately.

Since communications and networking is vital to departments, redundant entrances to new buildings/renovations will be looked at during the initial design phase to be included in the overall scope of the project.

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

It is the responsibility of the contractor to notify O.U.P.S. at 1-800-362-2764, 72 hours prior to start of construction, excluding holidays and weekends, for all utility markings. Those utilities that are not listed with O.U.P.S. must also be notified by the contractor. The Ohio State University's Facility Operations Development must also be contacted prior to construction for the University's private utility locates.

It will be the responsibility of the project to obtain the necessary permits involved in placing Office of the CIO conduit/cable through public right of ways. Costs for this process must be preapproved by the project prior to obtaining the permits.

When crossing privately owned properties with Office of the CIO facilities, easements shall be coordinated by Office of the CIO Outside Plant Department and The Ohio State University's Physical Planning and Real Estate (PPARE) Department.

As-built drawings will be provided upon completion of installation of all Office of the CIO outside plant in Auto-Cad format and 2 paper copies. Construction prints shall be clearly marked as to the location of the conduit that was placed. Where structures and features exist in the field, measurements must be taken both perpendicular to an edge or face of the structure and distance must be shown from the closest corner, beginning, or end of the existing structure. If no such references can be demonstrated, the Contractor shall establish a baseline reference that can be located easily in the future. All conduit will show a final measurement, e.g., 788'F. Wherever the ductbank crosses over or under existing utilities, the contractor must identify the service and pipe diameters crossed. Construction shall leave separation between found utilities which will be dictated by the utility crossed. The vertical separation shall be documented on the as-built. Vertical depths must be shown on the as-built drawings from the top of duct (encasement) to the existing grade. Whenever there is a change from the 36" standard cover due to unforeseen obstacles, Office of the CIO must be notified as to the problem prior to change. It shall be required that the FOD Mapping staff is notified to take GPS readings while the newly placed conduit and/or utilities are exposed.

### **1.3.2 REQUIREMENTS**

All new facilities or renovations will be subject to meet minimum requirements. A minimum of 2-4" (I.D.) PVC encased will be required for every new building for the placement of voice, data, and video. Conduit is to be placed at 36" below grade to top of encasement, unless approved by Office of the CIO, for each entrance.

Conduits will not feed building to building.

Duct banks will be placed as straight as possible, with bends kept at a minimum there will a minimum of a 20' radius on all conduit installations requiring bends. There will be no more than 180 degrees of bend in a section. Office of the CIO Outside Plant Department must approve all duct bank/manhole installations prior to start.

A Kevlar pull string or a measure tape shall be installed and tied off in each conduit. Pull wires used in outside conduit shall be stainless steel or copper; #12 AWG or strings shall be of the Kevlar type. From the MPOE (main point of entry), rigid metallic conduit will be used inside the building to the EF (entrance facility). The entrance facility must be within 50' of the MPOE. The minimum size for the Entrance Facility (EF)/Main Distribution Frame (MDF) is 400 square feet. The preferable dimensions are 20'x20'. All usable walls will be covered in 3/4" x48"x96" type APA A-D Group 1 plywood, fire retardant treated, with the A side facing the room. These rooms will be shared with computers, telephone equipment and data network equipment and racks. Office of the CIO shall be contacted for final dimension approval.

### **1.3.3 UNDERGROUND**

All underground conduits and ducts, rigid or PVC, added to a project shall be added in groups of 2, 4, 6, 8, 10, 12 or more. Under no circumstances are single underground conduit runs acceptable.

All underground conduit, duct bank and raceways shall be concrete encased (2500psi minimum). Additional reinforcement is to be used when crossing roadways or when recommended by the University Architects' Project Manager.

The minimum separation for communications ducts and power ducts in a joint trench environment is 3" (8 cm) of concrete, 4" (10 cm) of masonry or 12" (30 cm) of well-tamped earth. All communications ducts shall also be a minimum of 48" from steam pipes and condensation lines. If crossing perpendicular, Gillsulate insulation (or

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

Office of the CIO/FOD approved equal) must be placed over the top or underneath the encasement to reduce the risk of damage due to heat. The minimum depth for buried conduit and ducts is 36" to the top of the encasement from grade or underside of roadbed to top of concrete.

When communication ducts run parallel to steam lines, a minimum of a 2' separation is required, and Gillsulate insulation must be on the side facing the steam line to reduce the risk of damage due to heat. All other duct separations must comply with the National Electric Code.

Rigid steel conduit, encased in reinforced concrete with 5/8" rebar placed on 5" on center shall be used in any location subject to abuse, such as under roadways, slabs or foundations.

All underground conduits shall be 4" inside diameter.

All necessary precautions shall be taken by the contractor during construction to prevent the lodging of dirt, plaster, concrete or trash in all conduit. All conduit in floors, concrete or below grade shall be swabbed free of debris and moisture before wires are pulled. All conduit shall have duct plugs (expandable mechanical) installed at the building entrance to prevent water migration into the building. All building entrances will be sloped to drain back towards the manhole. Under no circumstances will a manhole be placed above the entrance to a building allowing it to drain towards the building.

### **1.3.4 TUNNELS**

Where conduit, ducts or cable trays are in tunnels, they shall be kept at least 24" from parallel runs of flues, steam pipes, hot gas pipes, hot water pipes or any other utility line which is hot during normal operation of the facility it serves. It is the preference of Office of the CIO Outside Plant Department that all communication cabling is placed opposite the steam side of tunnels. All conduit sections crossing steam lines shall be rigid and shall be provided with a means of insulation from the steam lines, unless a written exception is provided by the FOD Design & Construction Project Manager and Office of the CIO Outside Plant Department.

### **1.3.5 TRAPS**

All conduit, tubing, raceways, ducts and duct banks shall be installed in such manner to insure against collection of trapped condensation. Raceway runs shall be arranged to be void of traps.

When conduit passes through exterior concrete walls of any facility, the entrance shall be watertight. Pipe sleeves, at the conduit entrance, shall be sized large enough to place Link Seals between the sleeves and entrance conduit. Link Seals will be placed on both sides of the entrance.

### **1.3.6 TYPES**

Abandoned gas, water, steam and any pipes that might contain asbestos insulation shall not be used as telecommunications and networking conduit under any circumstances.

Four types of conduit are accepted for underground conduit systems. Project specifications will detail the types of conduit to be used in the various locations covered by the project.

Rigid galvanized steel conduit with threaded fittings. This conduit shall be installed with concrete casing in areas subject to abuse. If not concrete encased, this conduit shall be painted with 2 coats of coal tar base paint or have epoxy coating applied by manufacturer.

Schedule 40 PVC conduits. This conduit shall be installed with concrete encasement. No PVC conduit is acceptable without concrete, unless specified by Office of the CIO Outside Plant Department.

"C"-Duct conduit: This conduit shall be installed only with concrete encasement.

HDPE SDR11 or Bore Guard schedule 40: These are to be used for only directional boring. Boring must be preapproved by Office of the CIO.

Rigid steel conduits installed underground without concrete encasement shall be field-wrapped with 0.01" thick pipe-wrapping plastic tape applied with a 50 percent overlap, or shall have a factory applied plastic resin, epoxy

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

or 2 coats of a field-applied coal tar specifically made for this purpose. If the coal tar coating method is used, the contractor shall notify Office of the CIO prior to backfilling for inspection and approval of the coating before the conduit is covered.

Field wrapping or coating shall extend to 6" above ground level where conduit is installed by a pole or side structure or inside a pedestal.

The duct encasement shall be rectangular in the cross section and be a minimum concrete thickness of 2" around any conduit. The duct encasement shall be sized and placed as shown on construction documents.

All conduit and ducts must be terminated with bell ends at the manhole, facility or other termination point.

Duct spacers shall be provided at a maximum of 5' intervals. Conduit shall be anchored at 3'-6" intervals and at each spacer to prevent duct floating during concrete installation.

### **Emergency phones**

#### **1.3.7 Entrance Facility**

The Entrance Facility (EF) in the building must be placed within 50' of the MPOE (main point of entry). At the MPOE of the building, rigid metallic conduit (number of rigid metallic conduits equal them number of conduits entering the building) must be placed to the EF. All unlisted OSP cables will be placed in rigid conduit.

### **1.4 MANHOLES**

#### **1.4.1 GENERAL**

Manhole sizes may vary depending on space limitations. All manholes shall be placed in accordance with the manufacturer's specifications and all required safety regulations. All manholes shall be placed with a collar height of 18" minimum. Locking lids are required and shall be 30" in diameter with "COMMUNICATIONS" engraved on the lid. Manhole lids will not have recessed handles that pull out. All holes will be precast. See material list for acceptable manufacturer and part numbers.

Handholes must be approved by an Office of the CIO Outside Plant Designer.

The maximum distance between manholes connected in any one run shall not exceed 500'. Unless approved by Office of the CIO Outside Plant Department.

All telecommunication manholes /handholes must be placed in accordance with manufacturer's specifications unless special conditions are approved by Office of the CIO Telecommunications and Networking Outside Plant Department.

All Telecommunication Precast manholes/handholes shall include the associated hardware package (for racking), ladder, frame and cover, and collar (neck), for the specific structure being placed. Note: Lids must be marked as Communications.

See below for approved product vendor or OCIO approved equal:

#### **Concrete Precast Manholes/Handholes:**

Oldcastle Hartford Concrete Products  
1400 North Wabash Avenue  
P.O. Box 660  
Hartford City, Indiana 47348-0660  
1-800-428-8110  
Telefax: 765-348-3121

#### **1.4.2 Manhole Interior**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016



## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

All materials used in a manhole shall be resistant to corrosion. All steel shall be galvanized or zinc coated. All racking in manholes shall be in accordance with manufacturers' specifications. Manholes shall have pulling rings opposite to the conduit entrance on each wall.

### **1.4.3 Restoral**

All surfaces must be restored to like or better condition as soon as possible. Where settling occurs, it is the responsibility of the contractor to correct the given area and take appropriate measures to reseed and regrade as necessary at no additional charge to the project or Office of the CIO. The contractor is responsible for 1 year from project completion date.

### **1.5 SPECIAL CONSIDERATIONS**

For the items listed below Outside Plant services must be installed into the building prior to being able to install service. Notification must be given to Office of the CIO at least 6 weeks in advance to needing service. If temporary service must be placed it will be at the contractor/project expense. All service orders must be on company letter head (or microform if a University entity) and faxed to 614.688.3425. For questions regarding service contact 614.688.HELP option 2.

#### **EMERGENCY PHONES**

1. Cable will have water blocking compounds to prevent intrusion of moisture.
2. Materials suitable for -40 degree C to +80 degree C operation range.
3. Cable shall be Mohawk Versalan Cat 6 or OCIO approved equal.
4. Lightning protectors must be provided for both ends of cable. All four pairs of the cable must be protected. Each unit must be grounded at both ends. Protectors shall be or equal to L-Com part # AL-Cat6JW or L-Com HGLN-Cat6J or Office of the CIO-approved equal.
5. Electrical contractor to provide ground at stanchion.
6. One 2" conduit will be placed for low voltage communications to each stanchion from the nearest building telecommunications room. Once inside the building, the 2" conduit will be rigid metallic conduit.
7. Meets Category 6 transmission requirements of ANSI/TIA/EIA 568C.

## **APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### **SECTION VI: DEFINITIONS**

#### **COMMUNICATION OUTLET**

Any outlet designated for voice, data, or video. The termination point of the station wire will have an RJ11, RJ41, RJ45, BNC, F connector, or any other modular jack assembly installed. This outlet will be used for the connection of telephone, modem, data path, balun, or other device used to establish voice, data, or video communications.

**DATA TERMINATION JACK** (*SEE* Communication Outlet)

**TELEPHONE JACK** (*SEE* Communication Outlet)

#### **UNDERGROUND CABLE**

The cable that enters the building from the Campus Distribution Network.

**ENTRANCE CABLE** (*SEE* Underground Cable)

**OUTSIDE PLANT CABLE** (*SEE* Underground Cable)

#### **INTERMEDIATE DISTRIBUTION FRAME (IDF)**

The point where the riser cables and the station wire (ISW) come together. There can be more than one IDF in a building or on a floor.

#### **MAIN DISTRIBUTION FRAME (MDF)**

That point in the building where the underground cable is terminated on 66M150 type blocks. The riser cable is also terminated on 66M150 blocks at this location. The underground cable is cross-connected to the riser cable by a jumper.

#### **RISER CABLE**

The cable that runs between the IDF and the MDF.

#### **JUMPERS**

Two wires (1 pair) that connect the underground cable pairs to the riser cable on the 66M150 blocks at the MDF and the station wire to the riser cable at the IDF.

**CROSS-CUT WIRE** (*SEE* Jumpers)

#### **SPLICE**

A point where two cables are mechanically connected to each other.

#### **STATION WIRE**

A wire or cable used to connect the communication outlet to the IDF. This is to be a 3 pair wire without shield, 4 pair wire without shield, coaxial, or other as required.

**INSIDE WIRE (ISW)** (See Station Wire)

#### **TBB**

Telecommunications Bonding Backbone.

#### **“OR OCIO APPROVED EQUAL”**

Whenever the term “or OCIO approved equal” appears in this document it means the product must be the same size, shape, color and function as the product specified.

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### CATV Specifications for 75 Ohm Coaxial Cable

#### Series 6 Cable P/N= GF-URS-6 (non-plenum type)

All cable shall be "Quad Shield."

Minimum SRL shall be -20 dB 5 to 950 MHz and -15 dB 950 to 2200 MHz.

Minimum Velocity of Propagation shall be 85%.

Maximum attenuation for non-plenum type cable at 68 degrees F (20 degrees C) is listed in the following table:

Frequency in MHz	dB/100ft	
1	.25	
10	.66	
50	1.41	
100	1.92	
200	2.64	
400	3.73	
700	5.05	
900	5.79	
1000	6.11	
1200	6.73	
1450	7.49	
1800	8.43	
2200	9.35	
2500	9.97	
3000	10.92	

Maximum attenuation for plenum type cable at 68 degrees F (20 degrees C) is listed in the following table:

#### P/N= GF-UR-6-PL (Plenum type)

Frequency in MHz	dB/100ft	
1	.38	
10	.70	
50	1.48	
100	2.01	
200	2.86	
400	4.23	
700	5.96	
900	6.96	
1000	7.45	
1200	8.25	
1450	9.34	
1800	10.69	
2200	11.54	
2500	11.70	
3000	13.07	

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

### Series 11 Cable P/N= GAF-URS-11-MH (Non-plenum type)

All cable shall be "Quad Shield."

Minimum SRL shall be -20 dB 5 to 950 MHz and -15 dB 950 to 2200 MHz.

Minimum Velocity of Propagation shall be 85%.

Maximum attenuation for non-plenum type cable at 68 degrees F (20 degrees C) is listed in the following table:

Frequency in MHz	dB/100ft	
1	.17	
10	.45	
50	.89	
100	1.21	
200	1.68	
400	2.37	
700	3.27	
900	3.77	
1000	3.95	
1200	4.46	
1450	5.08	
1800	5.58	
2200	6.29	
2500	6.79	
3000	7.58	

Maximum attenuation for plenum type cable at 68 degrees F (20 degrees C) is listed in the following table:

### P/N= GAF-UR-11-PL (Plenum type)

Frequency in MHz	dB/100ft	
1	0.15	
10	0.45	
50	.90	
100	1.28	
200	1.85	
400	2.75	
700	3.92	
900	4.72	
1000	5.04	
1450	6.67	
1800	7.71	
2200	8.50	
3000	9.88	

# APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

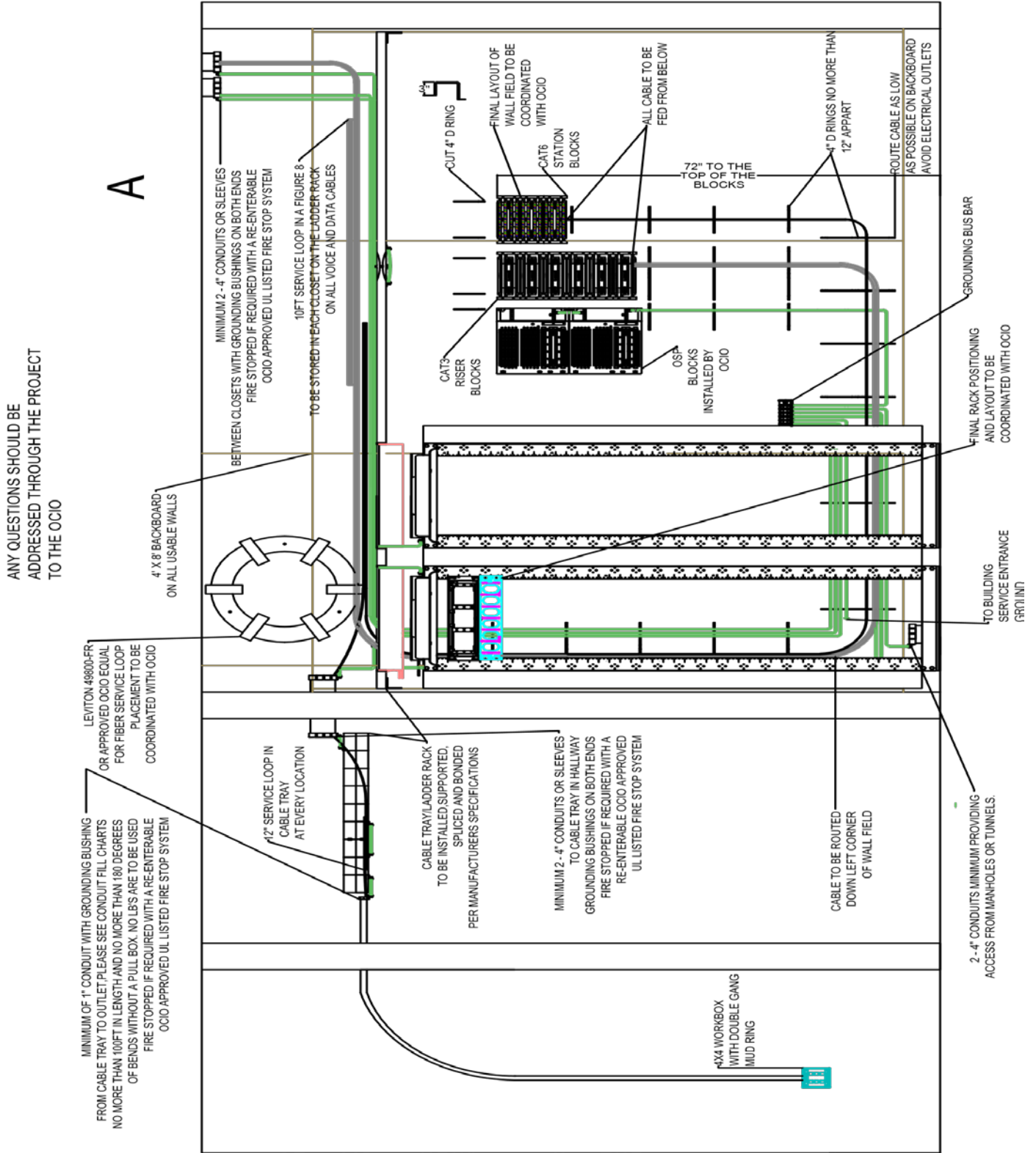


Exhibit A

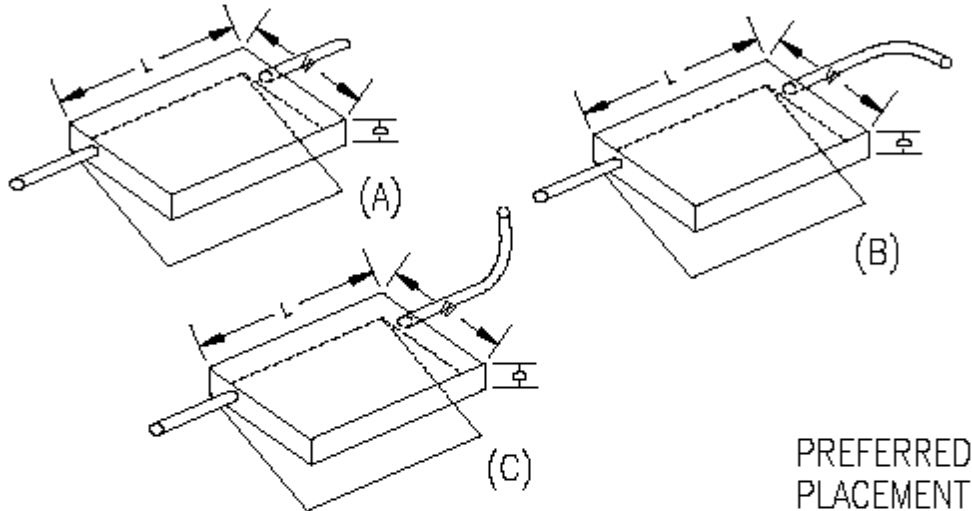
**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

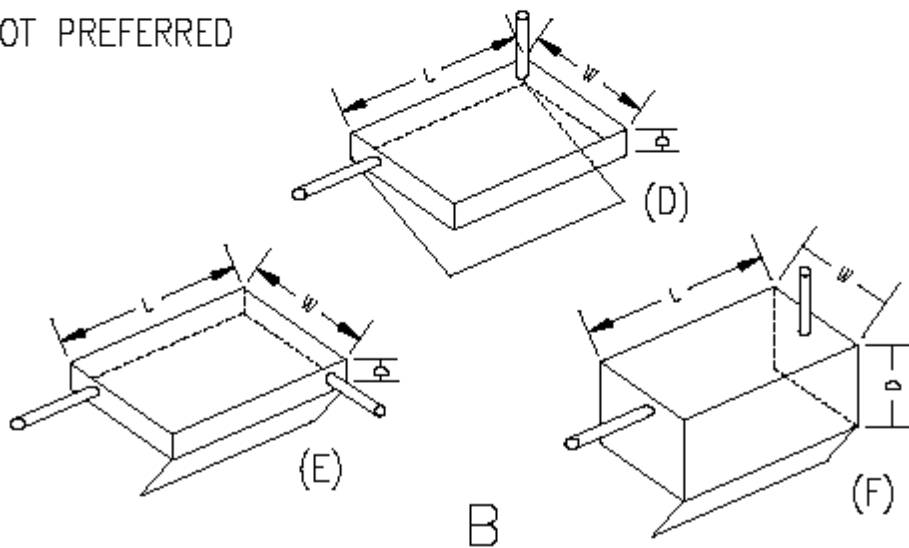
**PULL AND SPLICES BOXES**

A PULL BOX SHOULD BE PLACED WHERE CONDUIT RUNS EXCEED 100 FEET IN LENGTH OR CONTAIN THE EQUIVALENT OF MORE THAN TWO 90-DEGREE BENDS. CONDUIT SHOULD ENTER AND LEAVE THROUGH OPPOSITE ENDS OF THE BOX. NO BENDS SHOULD BE MADE INSIDE THE BOX. IF A 90-DEGREE TURN IS REQUIRED AT A BOX, IT IS PREFERABLE TO PLACE IT ADJACENT TO THE BOX, AS ILLUSTRATED IN (B) AND (C). DO NOT PLACE THEM AS ILLUSTRATED IN (D), (E), AND (F).

THESE SAME CONSIDERATIONS APPLY TO SPLICE BOXES PLACED AT TURNS.



NOT PREFERRED



**Exhibit B**

See Exhibit C for sizes.

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

**MINIMUM RECOMENDED SIZES OF PULLBOXES AND  
SPLICE BOXES**

If slip sleeves, gutters, or open sections of conduit are used instead of pull boxes, the opening should be as long as the pull box specified below.

PULL BOX SIZES FOR TWO CONDUITS (IN.)											
Nominal Conduit Size (in.)	Configurations  (a) or (b) or (c)			Configurations  (e)			Configurations  (f)			For each additional conduit add (in)	
	W	L	D	W	L	D	W	L	D		
	1	4	16	3	8	16	3	4	16		8
1-1/4	6	20	3	10	18	3	6	18	10	3	
1-3/8	8	27	4	12	24	4	8	24	12	4	
2	8	36	4	14	30	4	10	30	14	5	
2-3/8	10	42	5	16	36	5	12	36	16	6	
3	12	48	5	18	42	5	15	42	18	6	
3-3/8	12	54	6	21	48	6	15	48	21	6	

SPLICE BOX SIZES FOR TWO CONDUITS (IN.)											
	Configurations  (a) or (b)			Configurations  (d) or (e)							
	W	L	D	W	L	D					
	1	12	32	4	12	32			8	4	
1-1/4	14	36	5	14	36	10	6				
1-3/8	18	39	6	18	39	12	8				
2	20	42	7	20	42	14	9				
2-3/8	24	48	8	24	48	16	10				
3	30	54	9	30	54	18	12				
3-3/8	36	60	10	36	60	21	12				
4	42	66	11	42	66	24	12				

**Exhibit C**



**APPENDIX M- COMMUNICATIONS WIRING STANDARD**2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016**MINIMUM BEND RADIUS OF CONDUITS**

SIZE OF CONDUIT INCHES	CROSS SECT AREA SQ. INCHES	MINIMUM RADIUS OF CONDUIT BEND
		NON-LEAD SHEATH INCHES
0.75	0.53	5
1	0.86	6
1.25	1.5	8
1.5	2.04	10
2	3.36	12
2.5	4.79	15
3	7.38	18
3.5	9.9	21
4	12.72	24
4.5	15.94	27
5	20	30
5.5	28.89	35

**Exhibit D**

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

**CAT 6 CONDUIT CABLE FILL  
WITH 180 DEGREES OF  
BENDS**

CONDUIT TRADE SIZE	# OF CABLES
1"	4
1.5"	9
2"	16
2.5"	30
3"	45
4"	75

**CAT 6A CONDUIT CABLE FILL  
WITH 180 DEGREES OF  
BENDS**

CONDUIT TRADE SIZE	# OF CABLES
1"	1
1.5"	3
2"	6
2.5"	11.9
3"	17
4"	29

**CAT 6 CONDUIT CABLE FILL  
NO BENDS/OFFSETS**

CONDUIT TRADE SIZE	# OF CABLES
1"	6
1.5"	14
2"	24
2.5"	42
3"	65
4"	108

**CAT 6A CONDUIT CABLE FILL  
NO BENDS/OFFSETS**

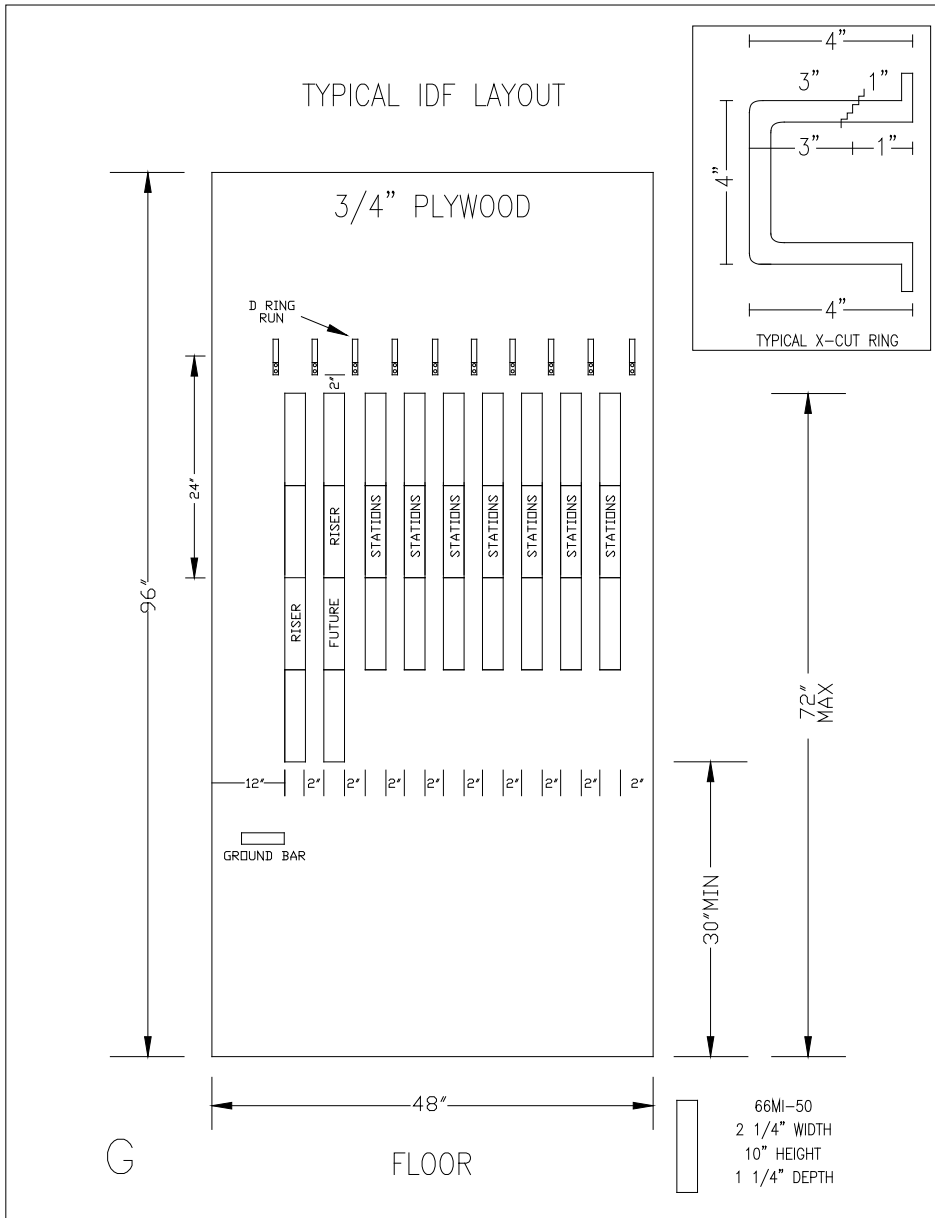
CONDUIT TRADE SIZE	# OF CABLES
1"	2
1.5"	5
2"	9
2.5"	16
3"	25
4"	42

**Exhibit E**



**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016



**Exhibit G**

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

Pair	TIP COLOR	PAIR COLOR CODE	RING COLOR
1	White-Blue		Blue-White
2	White-Orange		Orange-White
3	White-Green		Green-White
4	White-Brown		Brown-White
5	White-Slate		Slate-White
6	Red-Blue		Blue-Red
7	Red-Orange		Orange-Red
8	Red-Green		Green-Red
9	Red-Brown		Brown-Red
10	Red-Slate		Slate-Red
11	Black-Blue		Blue-Black
12	Black-Orange		Orange-Black
13	Black-Green		Green-Black
14	Black-Brown		Brown-Black
15	Black-Slate		Slate-Black
16	Yellow-Blue		Blue-Yellow
17	Yellow-Orange		Orange-Yellow
18	Yellow-Green		Green-Yellow
19	Yellow-Brown		Brown-Yellow
20	Yellow-Slate		Slate-Yellow
21	Violet-Blue		Blue-Violet
22	Violet-Orange		Orange-Violet
23	Violet-Green		Green-Violet
24	Violet-Brown		Brown-Violet
25	Violet-Slate		Slate-Violet

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

**Exhibit H**

Group No.	BINDER GROUP COLOR CODE
	Binder Group
1	Blue-White
2	Orange-White
3	Green-White
4	Brown-White
5	Slate-White
6	Blue-Red
7	Orange-Red
8	Green-Red
9	Brown-Red
10	Slate-Red
11	Blue-Black
12	Orange-Black
13	Green-Black
14	Brown-Black
15	Slate-Black
16	Blue-Yellow
17	Orange-Yellow
18	Green Yellow
19	Brown-Yellow
20	Slate-Yellow
21	Blue-Violet

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

22	Orange-Violet
23	Green-Violet
24	Brown-Violet
25	Slate-Violet

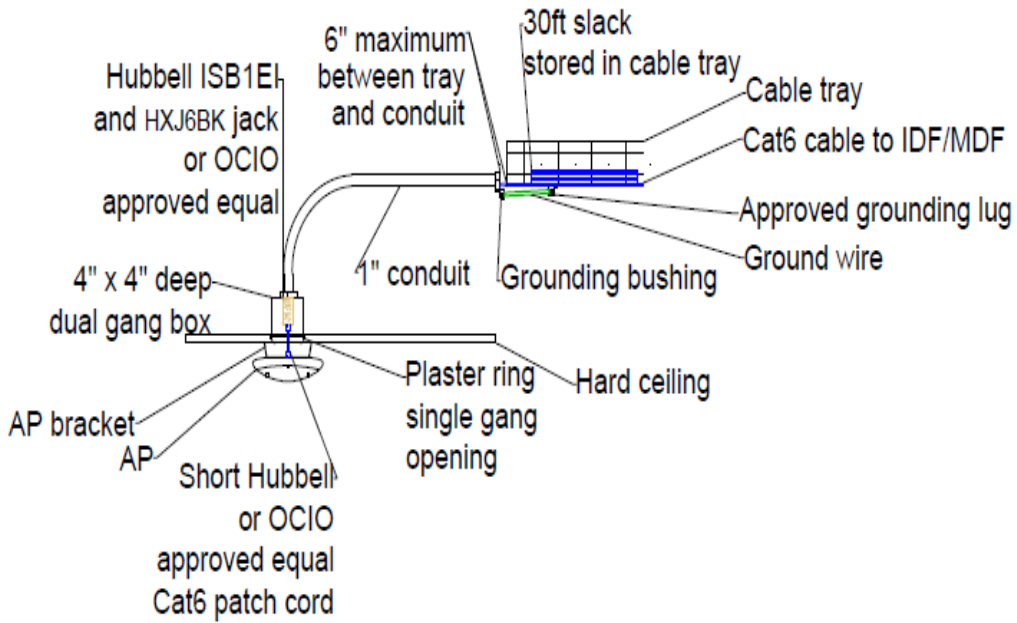
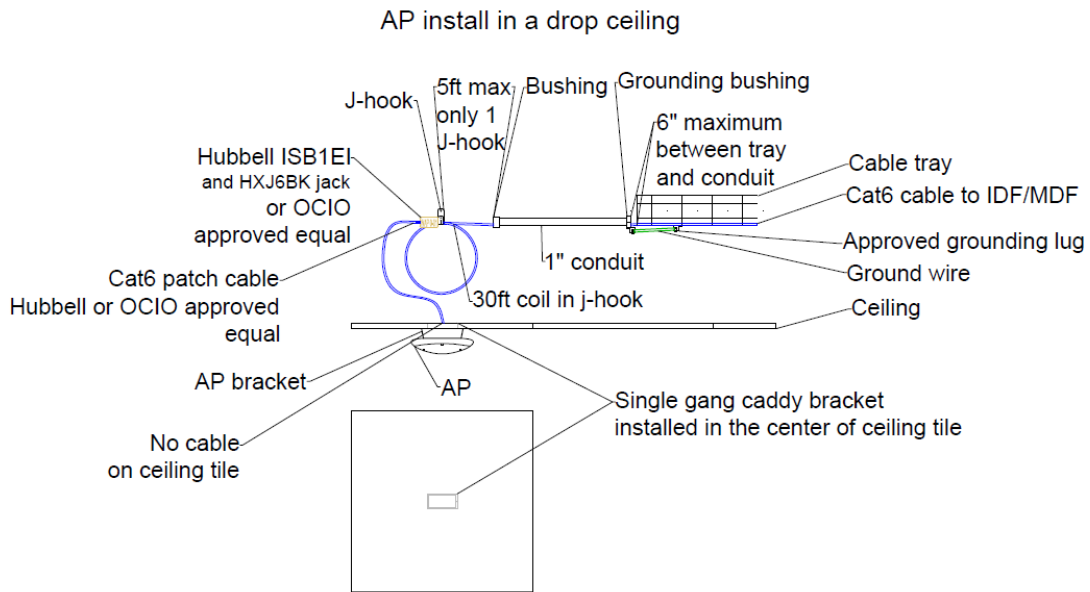
**Exhibit I**

JACK WIRE CODE	JACK COLOR	CODE	INSIDE WIRE COLOR
RED			BLUE-WHITE
GREEN			WHITE-BLUE
BLACK			ORANGE-WHITE
YELLOW			WHITE-ORANGE
BLUE			GREEN-WHITE
WHITE			WHITE-GREEN

**Exhibit J**

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

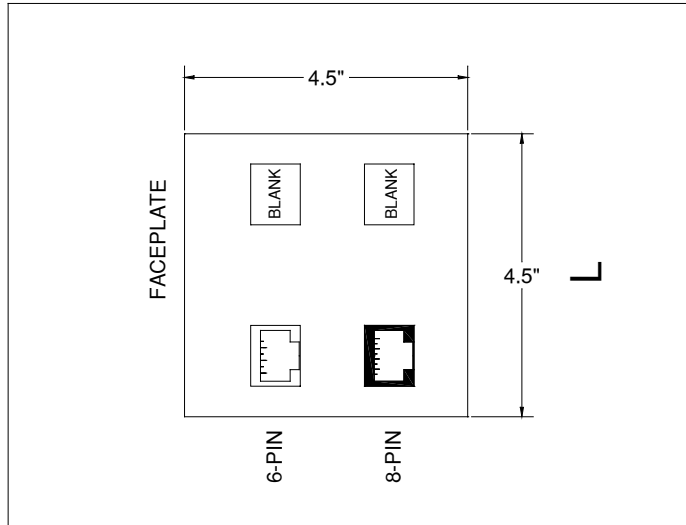


**Exhibit K**



**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

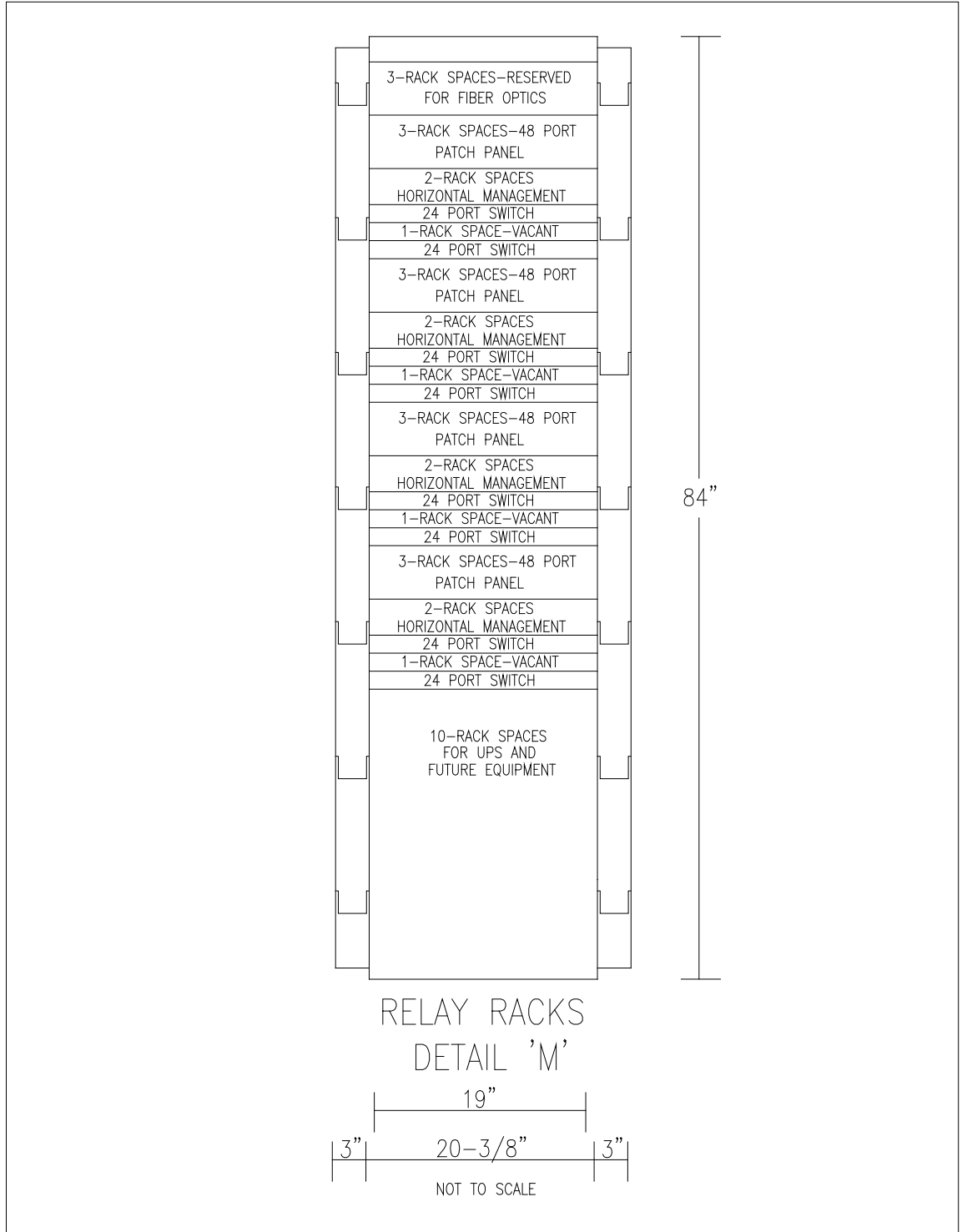
2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016



**Exhibit L**

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

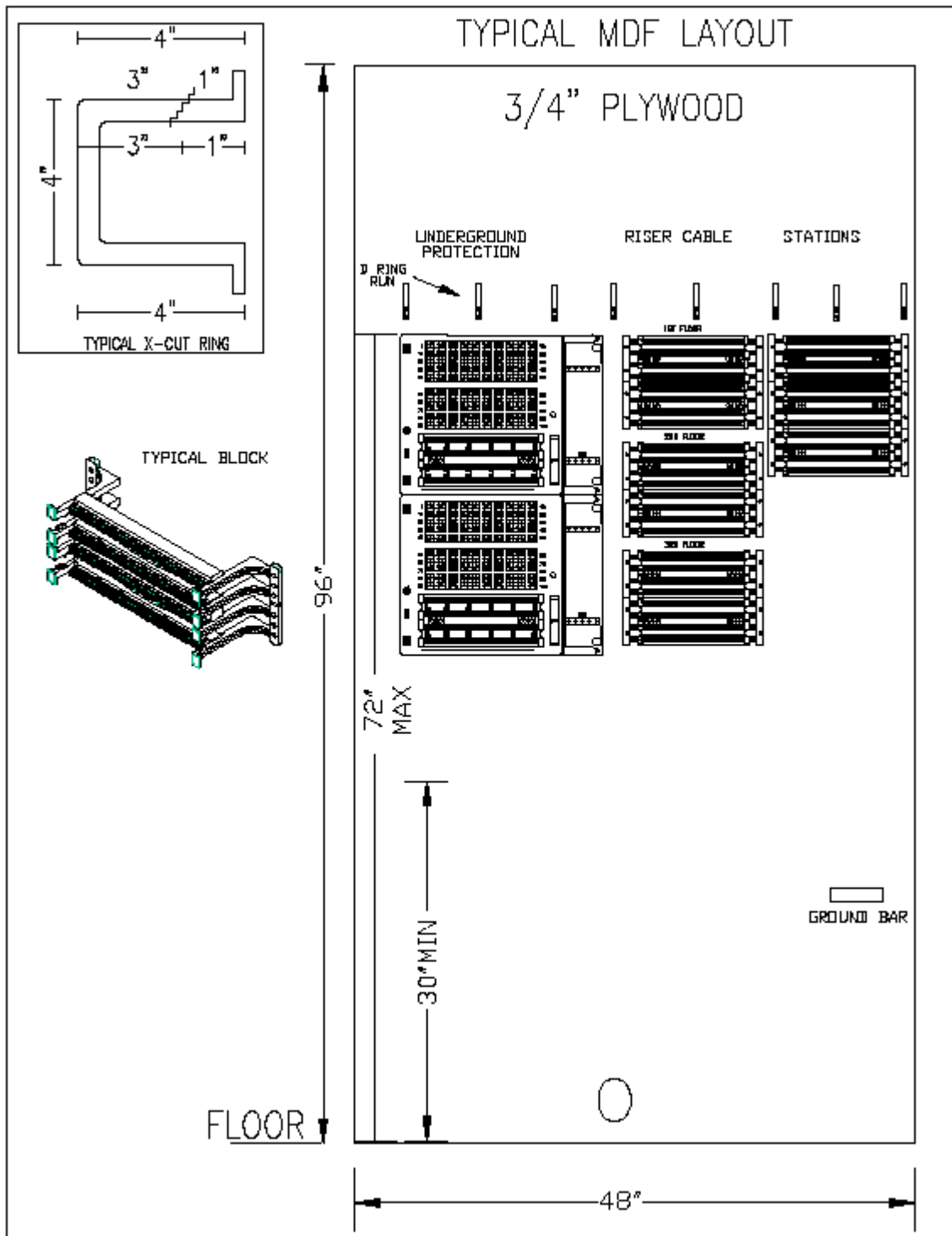
2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016



**Exhibit M**

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

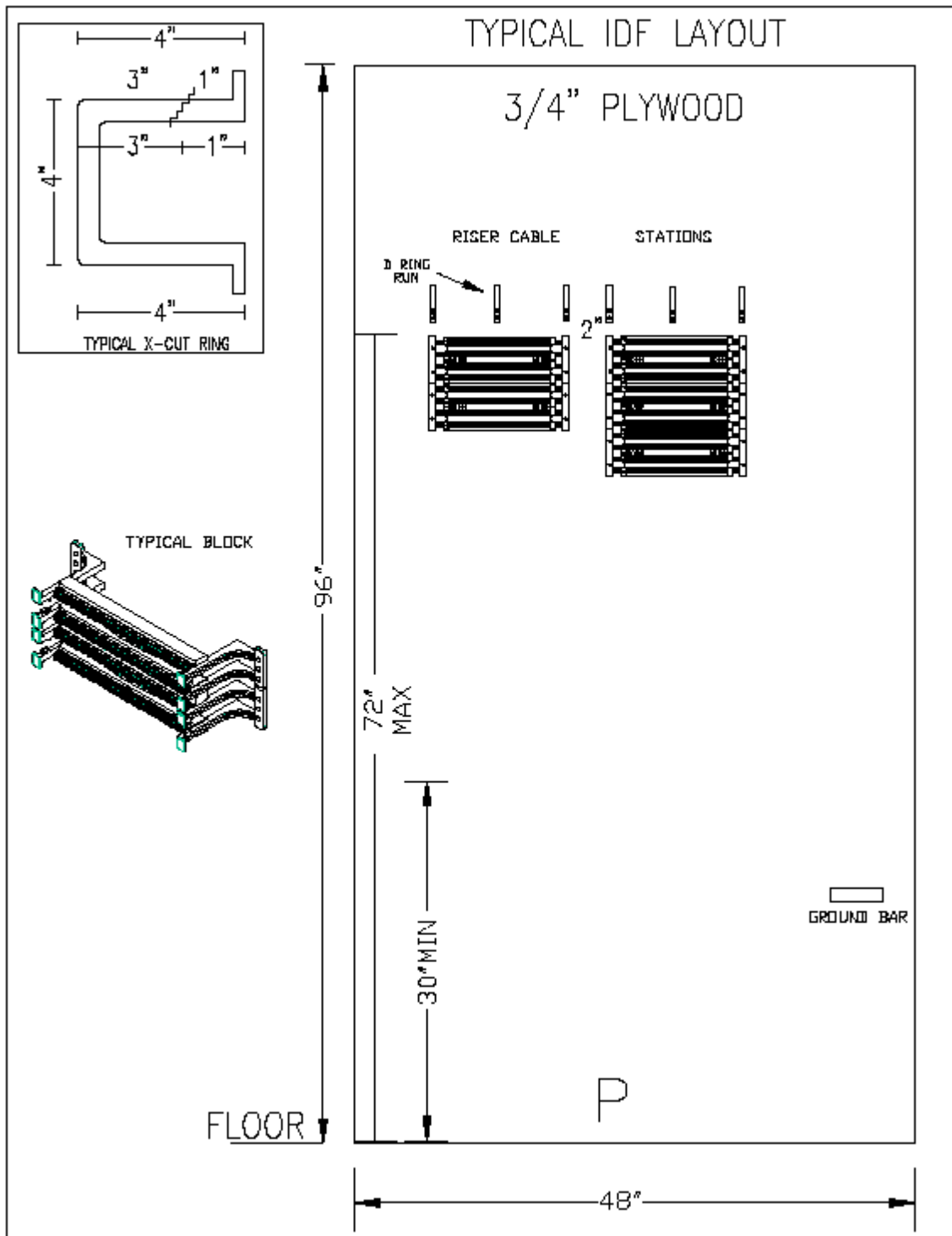
2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016



**Exhibit O**

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016



**Exhibit P**

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

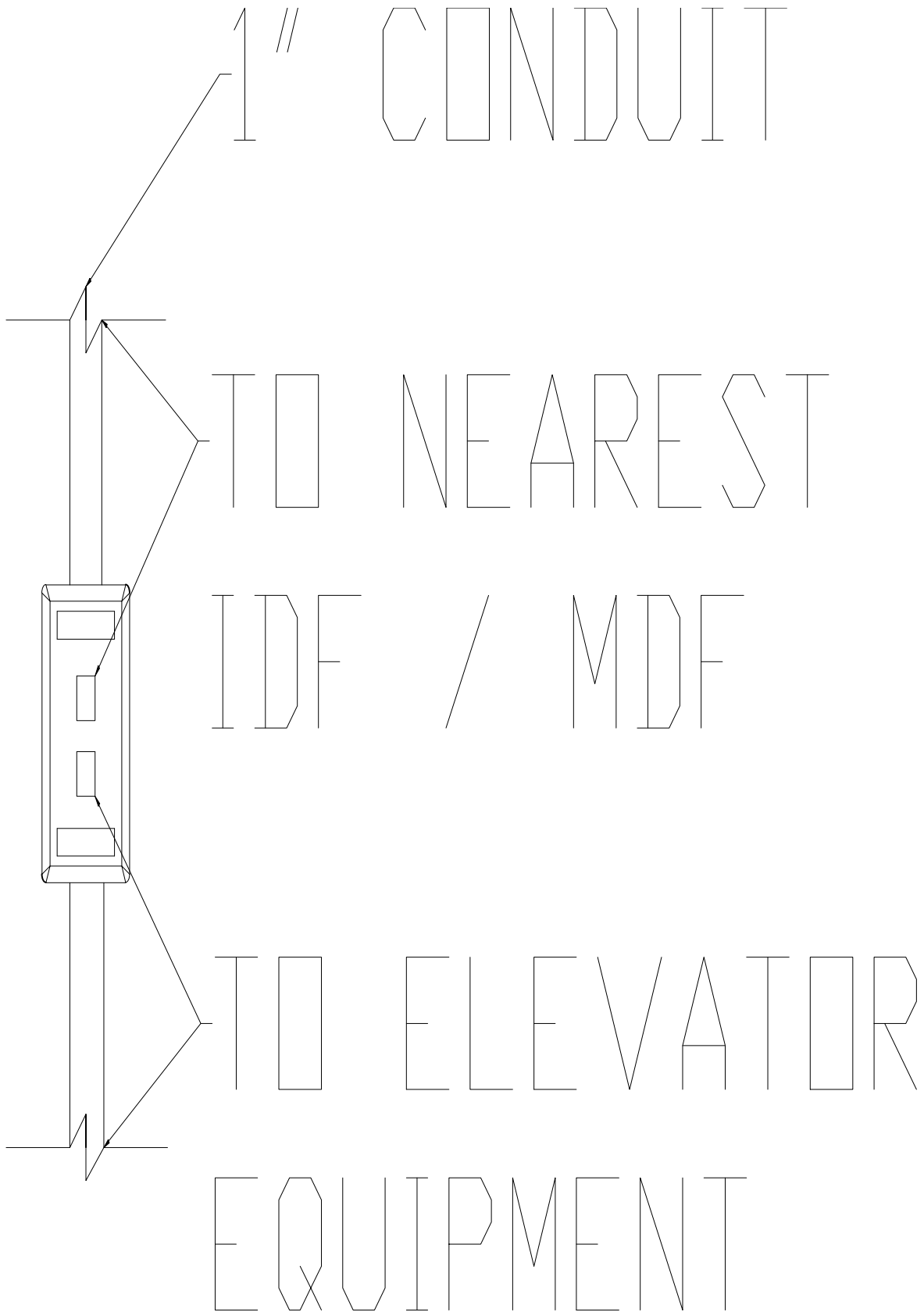
TBB sizing chart

<b>TBB/GE linear length m (ft)</b>	<b>TBB/GE size (AWG)</b>
less than 4 (13)	6
4 – 6 (14 – 20)	4
6 – 8 (21 – 26)	3
8 – 10 (27 – 33)	2
10 – 13 (34 – 41)	1
13 – 16 (42 – 52)	1/0
16 – 20 (53 – 66)	2/0
20 – 26 (67 – 84)	3/0
26 – 32 (85 – 105)	4/0
32 – 38 (106 – 125)	250 kcmil
38 – 46 (126 – 150)	300 kcmil
46 – 53 (151 – 175)	350 kcmil
53 – 76 (176 – 250)	500 kcmil
76 – 91 (251 – 300)	600 kcmil
Greater than 91 (301)	750 kcmil

**Exhibit Q**

**APPENDIX M- COMMUNICATIONS WIRING STANDARD**

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

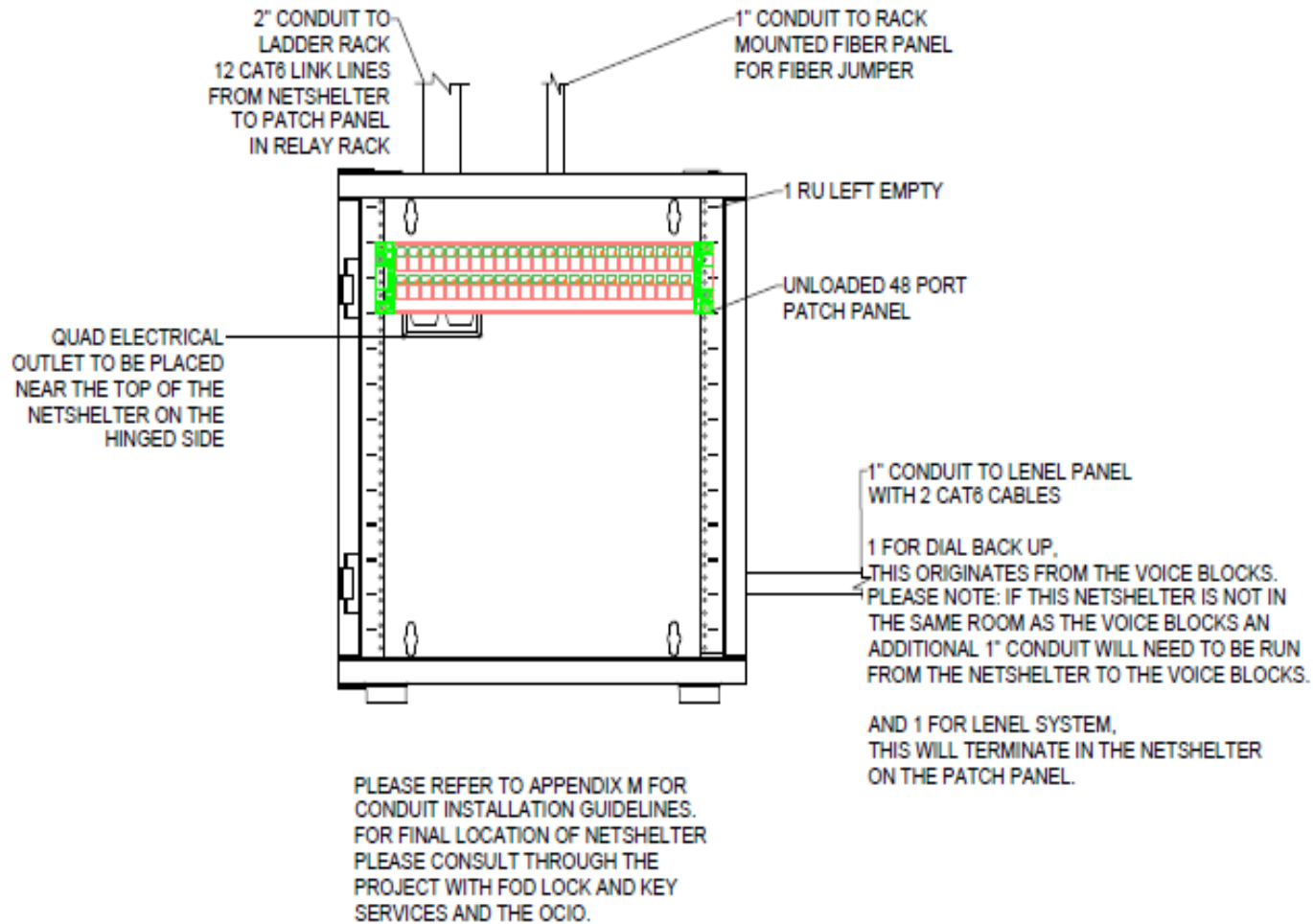


**Exhibit R**

## APPENDIX M- COMMUNICATIONS WIRING STANDARD

2006 Edition, Published January 1, 2006; Division Revision Date: June 30, 2016

# S



### Exhibit S

End of Appendix M

**APPENDIX N**

2006 Edition, Published January 1, 2006; Division Revision Date: August 1, 2012

This section was incorporated into Appendix W



**APPENDIX O**

2006 Edition, Published January 1, 2006; Document Revision Date: November 15, 2000

**CLASSROOM DESIGN GUIDELINES**

The Ohio State University

PART I: ROOM GEOMETRICS	SEMINAR ROOMS (20 or less)	GENERAL PURPOSE CLASSROOMS (21-80)	LECTURE HALLS (81 or more)
<b>A. ASPECT RATIO (Length to Width)</b>	ideally length (dimension perpendicular to teaching center) shall be equal to width and shall not exceed 1.5 width	ideal aspect ratio length to width is 1.5:1	not applicable due to varying room shape -- effective sight lines for viewing entire teaching area and projected images are critical adherence to guidelines is mandatory (see PART III-D)
<b>B. CEILING HEIGHT</b>	8' minimum	10' minimum in Rooms to 49 capacity; 12' minimum in Rooms 50-74 capacity; 14' minimum in Rooms 75-80 capacity	10' minimum at rear wall; front wall viewing area height to be minimum of [(room length / 6 + 4)feet] while maintaining clear sight lines from each seat
<b>C. TEACHING AREA DEPTH (Least Distance) (perpendicular measure from center of teaching wall to nearest student seat)</b>	minimum 6' if an identifiable teaching station is provided by furniture arrangement	minimum 10', 12' preferred	depth of teaching area dependent on stage dimensions and location of any fixed equipment such as demonstration bench or electronic lectern; general minimum 15 feet
<b>D. SIGHT LINES FROM EACH STUDENT SEAT TO CENTER OF TEACHING SURFACES</b>	Vertical: not > 20° from horizontal sight line of seated person  Horizontal: not > 45° from perpendicular line to each teaching surface from student seat	Vertical: ±15° from horizontal sight line of seated person  Horizontal: not > 45° from perpendicular line to each teaching surface from student seat	Vertical: ±15° from horizontal sight line of seated person  Horizontal: not > 30° from perpendicular line to each teaching surface from student seat
<b>E. FLOOR ELEVATION CHANGES</b>	not permitted	rooms with >70 capacity may provide tiered seating to improve sight lines from rear access as needed	same as Seminar Rooms
<b>F. CEILING ELEVATION CHANGES CEILING ANGLES WITH TEACHING WALL</b>	not permitted	normally flat--in rooms >70 capacity ceiling above teaching center may be angled to better reflect sound to rear of room	ceilings must be angled properly to provide for sound reflection from teaching center to rear portions of room

<p><b>G. SIDEWALL ANGLES WITH TEACHING WALL</b></p>	<p>normally perpendicular but may be angled for architectural reasons</p>	<p>normally perpendicular but may be angled for architectural reasons in smaller rooms (&lt;50 capacity)</p>	<p>sidewalls must not be parallel -- angle(s) with teaching all shall be determined from study of acoustics in each room depending on size and shape</p>
<p><b>H. TEACHING AREA ELEVATION</b></p>	<p>required to be same as seating area if a separate teaching area is demarked by furniture arrangement</p>	<p>ADA accessible platform required to be same as seating area except in rooms of &gt; 70 capacity where an ADA accessible platform not to exceed 7 inches in height may be provided for the teaching center.</p>	<p>must be at same elevation as entry corridors to "front" of lecture hall and adjacent classroom service rooms provide ADA accessible to &amp; from "stage" front and rear area</p>

PART II: SONIC CONDITIONS & CONTROLS	SEMINAR ROOMS	GENERAL PURPOSE CLASSROOMS	LECTURE HALLS
<b>A. ROOM SOUND QUALITY</b>	all rooms must feature a sonic environment which provides for good aural conditions at every student seat with particular attention to: 1) preventing unwanted sounds outside the room from entering through walls, floor, mechanical ducts or other openings into the room 2) preventing <b>interfering</b> sound reverberations within the room 3) providing for clear transmission of sounds from the teaching area to all student seats.		
<b>B. SOUND CONTROLS</b>	room enclosures shall have a sound transmission coefficient of at least 50 -- sound levels in empty room shall have ambient noise not greater than 35 db measured at average head height (44") for a seated person -- all walls must extend to structure -- doors shall not have louvers	same as Seminar Rooms	same as Seminar Rooms
<b>C. SOUND CONTROLS: INTERIORS</b>	teaching wall must be hard surface -- side and rear walls may have sound dampening material applied as needed -- ceiling shall provide a sound reflectant surface sufficient to carry sound from teaching center to all student seats but otherwise may use sound reduction material with a noise reduction coefficient of 0.6	same as Seminar Rooms except that rooms of >70 capacity may provide a sound amplification system for both live and recorded presentation and shall have acoustical shaping to insure good sound projection to rear seats	side walls shall be neither parallel nor of continuous hard surface expanse and have a sound transmission coefficient not less than 50 -- teaching wall must be of hard surface materials -- rear wall and side walls shall have sound dampening material applied to "tune" the room so that sound is adequately reflected without interfering reverberations -- ceilings shall be sloped or stepped and be a hard surface to directionally reflect sound -- any acoustical material on ceilings shall be applied carefully and usually only near side walls and rear wall -- designers are strongly encouraged to use services of an acoustician in Lecture Hall design

<p><b>D. SOUND AMPLIFICATION</b></p>	<p>optional</p>	<p>optional in rooms up to 70 capacity -- rooms &gt;70 capacity may require an in-room voice amplification system with microphone and volume control accessible to the instructor -- audio line input with local control -- also amplification system must be able to accommodate an FM wireless system to serve 5% of student seats for hearing-impaired students -- designers must consult with staff from the OSU Office of Information Technology Classroom Facilities and Systems Design regarding need for a sound system in rooms &gt; 70 capacity</p>	<p>sound amplification system required to serve both live and recorded aural presentation -- a "hands-free" microphone is required, a wireless microphone is desirable -- system shall be capable of amplifying sound tracks of recorded material and an incoming telephone line -- sound shall be carried to 5% of seat stations to serve hearing-impaired students -- sound system levels to be controllable both from teaching area and from projection booth</p>
--------------------------------------	-----------------	---	--

PART III: VISUAL CONDITIONS AND CONTROLS	SEMINAR ROOMS	GENERAL PURPOSE CLASSROOMS	LECTURE HALLS
<b>A. LIGHT QUALITY AND INTENSITY</b>	<p>light levels must be uniform throughout the task area</p> <p>-- audience light levels shall be 40-50 foot candles for non-mediated instruction, audience light levels shall be 2-10 foot-candles for mediated and note taking instruction, chalkboard illumination shall be 60-70 foot-candles</p> <p>-- audience level measurements to be taken at desktop height</p>	<p>same as Seminar Rooms</p>	<p>same as Seminar Rooms with the inclusion of appropriate aisle/entrance lighting be uniform throughout task area -- all fixtures flush with the ceiling. Use parabolic fixtures, diffusers or other appropriate means to eliminating glare -- wall sconces may be appropriate in some instances</p>
<b>B. ARTIFICIAL LIGHT CONTROL</b>	<p>lighting controls shall be standardized in layout and location as much as possible -- all controls must be labeled clearly and adhere to all applicable ADA requirements and building regulations -- an entry lighting control shall be located at each room entrance, full room lighting controls shall be located on the wall with easy access from the teaching station -- indirect, dimmable fluorescent lighting shall be used to eliminate glare -- minimum lighting controls to have one zone for teaching area, one zone for audience, and on/off chalkboard light control -- in general, fluorescent light fixtures are to be flush with ceiling and run parallel with the teaching wall -- exact fixture orientation will depend on seating arrangement -- chalkboard lighting fixture type and placement to avoid interference with projection screen operation</p>	<p>same as Seminar Rooms except direct, dimmable fluorescent fixtures shall be used to achieve proper lighting levels in audience area</p>	<p>same as General Purpose Classrooms with these additions: dimmable incandescent fixtures may be substituted for fluorescent fixtures in teaching area -- optional lectern spots with separate controls may be used, placement and design of these fixtures must eliminate any chance of shadowing or bleeding onto the projection screen -- control panels shall be located near the instructors station on the wall offering easiest access -- a second full control panel must be provided in the projection booth or projection control area -- consideration for the ease of lamp replacement must be taken when choosing fixtures --</p> <p>*NOTE* rooms supporting specialized activities i.e. computer labs, distance learning or video conferencing need specialized considerations -- lighting specifications for such rooms shall be engineered individually</p>
<b>C. NATURAL LIGHT CONTROL</b>	<p>all fenestration openings must be equipped with light control devices which will eliminate natural light on the projection screen and permit room darkening to 5 foot candles at student stations even if direct sunlight is a factor (NOTE: this includes interior door glass) -- since frequent room darkening is required in classrooms, window area shall be minimized</p>	<p>same as Seminar Rooms</p>	<p>windows not recommended in Lecture Halls, otherwise, same as Seminar Rooms</p> <p>provide room darkening if needed in entry door vision panels</p>

<b>D. PROJECTED IMAGES -- ANGLES AND DISTANCES</b>	sight lines from average person's seated eye level (44") to center of projection screen(s) shall not exceed 45° from perpendicular in the horizontal plane -- student seats shall be no closer than 1.5 times a single image width nor farther than 6 times a single image height -- lowest part of projected image to be 36" - 48" AFF -- top of projection screen shall subtend an angle not > 35° from the horizontal sight line of average seated person	same as Seminar Rooms	same as General Purpose Classrooms except that student sight line angle shall be reduced to a maximum of 30 degrees from perpendicular in the horizontal plane  lowest part of projected image based on stage characteristics
<b>E. SURFACE REFLECTANCES</b>	reflectance values of surface finishes shall be within the following ranges: <ul style="list-style-type: none"> <li>• Ceilings 60-90%</li> <li>• Walls 40-60%</li> <li>• Floors 20-50%</li> <li>• Table or tablet-arm tops 30-50%</li> <li>• Chalkboards 20-30%</li> </ul>	same as Seminar Rooms	same as Seminar Rooms except for ceilings (see Part IX-B)

<b>PART IV: THERMAL CONDITIONS AND CONTROLS</b>	<b>SEMINAR ROOMS</b>	<b>GENERAL PURPOSE CLASSROOMS</b>	<b>LECTURE HALLS</b>
<b>A. IN-ROOM HVAC CONTROLS</b>	room HVAC controls shall be part of a building zone or whole building control system with tamper proof thermostats -- in-room systems or window units not permitted due to noise generation	same as Seminar Rooms	due to room volume and occupation of multiple building levels, in-room HVAC controls may be used -- install tamper-proof thermostats
<b>B. HVAC SYSTEMS</b>	air conditioning required -- shall be part of a building central system or at minimum a building area system -- in-room HVAC systems or window units not permitted due to noise generation -- air flow (supply/return) in room shall not move the projection screen	same as Seminar Rooms	same as Seminar Rooms  consider separate air handlers for one or groups of similar rooms
<b>C. TEMPERATURE AND HUMIDITY TOLERANCES</b>	Temperature and humidity should be maintained to meet the health and comfort requirements of the occupants	same as Seminar Rooms	same as Seminar Rooms

PART V: TEACHING SURFACES	SEMINAR ROOMS	GENERAL PURPOSE CLASSROOMS	LECTURE HALLS
<b>A. VERTICAL WRITING SURFACES</b>	<p>teaching wall must have black chalkboard (slate or steel with steel preferred) or optional whiteboard (chalkboard preferred) at 4' vertical height mounted 3' above finished floor -- tack strip and chart rail with movable mounting hooks required above writing surface, chalk tray required below entire length of the board -- writing surface on corridor sidewall optional -- to accommodate writing surface the teaching wall shall have no projections such as pilasters, columns, chases, etc.</p> <p>chalkboards must be properly illuminated (see Part III-A,B)</p>	<p>same as Seminar Rooms except that whiteboards are not permitted</p>	<p>chalkboards optional -- size of auditorium and intended use would dictate that chalkboard specifications for each room shall be engineered individually -- black chalkboards to be centered on the teaching wall only -- consider multi-level sliding and power operated chalkboards -- tack strip and display hooks not required</p> <p>installed chalkboards must be properly illuminated (see Part III-A,B)</p>
<b>B. VERTICAL DISPLAY SURFACES</b>	<p>provide one 3'x 4' tack board in room adjacent to entrance -- provide one 3'x 4' tack board in corridor for each group of two to five rooms (one or isolated single rooms do not require a corridor tack board)</p>	<p>same as Seminar Rooms</p>	<p>provide one 3'x 4' tack board inside and outside of each principal student entrance to room, or if a lobby area is adjacent to the principal entries, locate one 3'x 4' tack board in a prominent place</p>
<b>C. PROJECTION SCREENS</b>	<p>provide one 70" x 70", matte white manually operated projection screen in each room -- each screen shall be hung on brackets extending at least 6" from the wall or enough to clear all obstructions -- bracket attachment to the wall must support the weight of the screen and any dynamic loads applied during screen operation -- on hollow walls, brackets shall be fastened to a surface-mounted continuous 1x wood board with blocking behind (paint or stain) -- screens shall be hung 6 ft. above the chalk rail -- when there is not 6 ft. available the screen shall be hung as high as possible -- the center of the extended screen shall meet the viewing angles described in PART I-D and PART III-D</p>	<p>same as Seminar Rooms with following addition -- front wall installation of two 70" x 70" screens to allow simultaneous use of a screen and chalkboard</p>	<p>screen size, type and placement to be determined by consultation with the Office of Information Technology Classroom Facilities and Systems Design -- when an electric screen is utilized the controls shall be placed adjacent to the lighting controls in the teaching area and projection booth</p> <p>adhere to viewing angles described in Part III-D</p>
<b>D. TEACHER TABLE (movable)</b>	<p>optional</p>	<p>2' x 4' movable table minimum</p>	<p>Optional, same as General Purpose Classroom when desired</p>

PART VI: MOVABLE EQUIPMENT	SEMINAR ROOMS	GENERAL PURPOSE CLASSROOMS	LECTURE HALLS
<b>A. AUDIO-VISUAL EQUIPMENT</b>	Minimum requirements of every room shall be a wall mounted projection screen and an overhead projector on a cart -- each room shall permit the use of all current educational technologies -- all projects shall be coordinated with the Office of Information Technology Classroom Facilities and Systems Design	same as Seminar Rooms with addition of a second wall mounted projection screen	A full complement of audio/visual equipment shall be provided by each building project -- Minimum requirements shall be dual 35mm projection with remote control, dual overhead projectors on carts, 16mm projection, and full sound reinforcement -- all projects shall be coordinated with the Office of Information Technology Classroom Facilities and Systems Design
<b>B. TEACHING STATION MOVABLE EQUIPMENT</b>	Optional table-top lectern and teacher table	Table top lectern and teacher table -- optional free-standing podium	rooms may have a free-standing podium, provisions must be made to meet ADA regulations--layout of each podium to be determined by the Office of Information Technology Classroom Facilities and Systems Design
<b>C. STORAGE UNITS</b>	optional (see PART XIII-A)	same as Seminar Rooms except in rooms where video/data projectors are installed -- space may be required to house support equipment for video/data projection (see PART XIII-A)	all storage to be within service room (see PART XIII-A)



PART VII: FIXED EQUIPMENT	SEMINAR ROOMS	GENERAL PURPOSE CLASSROOMS	LECTURE HALLS
A. TV MONITORS	not recommended	not recommended	not recommended
B. SOUND REPRODUCTION AND REINFORCEMENT	optional	Optional -- rooms with > 70 capacity may require a sound system depending on room geometry and acoustical features-- (see PART II-D)	in-room system required -- project designers must consult with the Office of Information Technology Classroom Facilities and Systems Design (see PART II-D)
C. AUDIO-VISUAL EQUIPMENT CONTROLS	controlled at the device -- consult with the Office of Information Technology Classroom Facilities and Systems Design	controlled at the device -- consult with the Office of Information Technology Classroom Facilities and Systems Design	all machines controllable both from teaching area and projection booth -- consult with the Office of Information Technology Classroom Facilities and Systems Design
D. VIDEO/DATA PROJECTION	achievable with portable projection equipment and in-room mounted projection screen	fixed video/data projection and related equipment to be considered in some rooms -- to be coordinated with the Office of Information Technology Classroom Facilities and Systems Design	provide ceiling-mounted (or equivalent) projector to handle both video and data projection, including high resolution graphics and composite video images--audio from the video projection system is to be amplified by the room sound system—all projection systems, control panels, and related equipment to be coordinated with the Office of Information Technology Classroom Facilities and Systems Design
E. CLOCK	rear of room	rear of room	rear of room
F. CLASS BELL	locate in corridor	locate in corridor	locate in corridor
G. DEMONSTRATION BENCH (fixed)	optional	optional	optional in rooms where natural sciences are taught -- where specified, provide an instructor's fixed demonstration bench, minimum 8'x 4' deep, with acid resistant top and 120v power outlets

PART VIII: FURNITURE	SEMINAR ROOMS	GENERAL PURPOSE CLASSROOMS	LECTURE HALLS
<b>A. STUDENT SEATS</b>	student seats shall be selected to provide comfort for all size students -- provide sturdy armless chairs for classroom capacity -- chairs shall be designed so that rear legs project further than top of seat back	two options: 1) sturdy tablet arm chairs with usable writing surface >180 sq. in. with a minimum 12 in. in one dimension, or 2) tables and chairs. If tablet-arm chairs are used, 10% of all chair stations shall have color differentiated left-hand tablet arms unless the writing surface is >200 sq. in -- tables shall be minimum 18 inches deep and afford at least 30 inch width work space per student station -- aisle width per code and ADA regulation	two options: 1) fixed theater type seat with fold-up tablet arm having usable writing surface > 180 sq. in. with a minimum 12 in. in one dimension, or 2) loose armless chairs with strip tables -- provide stations for wheelchair at 5% of room capacity -- 10% of all tablet-arm stations shall be left-hand unless the writing surface is >200 sq. in. -- fixed seating shall be back- mounted to risers if possible
<b>B. STUDENT TABLES</b>	provide tables with at least 18 inch depth and 30 inch width work space per seat to afford minimum 3.75 sq. ft. of table space per student station	Same as seminar room	Same as seminar room
<b>C. SEATING FOR PEOPLE WITH DISABILITIES</b>	leave clear space in front -- do not block aisles -- location and number of seats per ADA guidelines	leave clear space in front -- do not block aisles -- location and number of seats per ADA guidelines	leave clear space in front -- do not block aisles -- location and number of seats per ADA guidelines
<b>D. TEACHING STATION</b>	If teacher workspace is not included in room furnishings, provide instructors desk or table at least 24 inches deep by 48 inches long and one armless chair  (In addition, see Part VI-B)	provide instructors desk or table at least 24 inches deep by 48 inches long and one armless chair  (In addition, see Part VI-B)	Same as General Purpose Classroom  (In addition, see Part VI-B)
<b>E. WRITING SURFACE AT STUDENT SEATS</b>	very durable, hard finish plastic laminate or equivalent required whether table top or tablet arm	same as Seminar Rooms	same as Seminar Rooms
<b>F. WASTE AND RECYCLING RECEPTACLES</b>	one located near room entrance(s)	same as Seminar Rooms	one located near room entrance(s) and at instructor's station

<b>PART IX: ROOM SURFACES</b>	<b>SEMINAR ROOMS</b>	<b>GENERAL PURPOSE CLASSROOMS</b>	<b>LECTURE HALLS</b>
<b>A. FLOOR FINISHES</b>	vinyl tile or rubber tile--(sheet vinyl not permitted) -- carpet may be considered	Same as Seminar Room	resilient tile required in seating areas, carpet in main aisles for sound control
<b>B. CEILING FINISHES</b>	light color materials preferred --acoustical drop surface preferred -- painted plaster or gypsum board acceptable -- unfinished structure not usually acceptable	same as Seminar Rooms except in rooms > 50 capacity--acoustical properties must be carefully planned to insure sound reflectance to rear of room and control of reverberations	shall be light colored non-reflective materials -- acoustical properties shall be the over-riding factor in selection and application of ceiling finish materials
<b>C. TEACHING WALL FINISHES</b>	if a teaching area is established, sound and light reflectance are the most critical factors -- wall finishes or coverings below chalkboards must be of easily cleanable material -- teaching walls shall be free of projections such as pilasters, columns, chases, etc., front teaching wall shall not contain windows	same as Seminar Rooms	same as Seminar Rooms
<b>D. OTHER WALL FINISHES</b>	gypsum board or concrete block, painted or textured are preferred -- light colors preferred -- in rooms with movable table and chair furniture, chair rails shall be considered	same as Seminar Rooms--sound reflectance is more critical in rooms with > 50 capacity (see Part II-C)	same as Seminar except that acoustical properties become more critical, especially rear wall and rear portions of side walls (see Part II-C)

<b>PART X: ELECTRICAL SERVICES</b>	<b>SEMINAR ROOMS</b>	<b>GENERAL PURPOSE CLASSROOMS</b>	<b>LECTURE HALLS</b>
<b>A. ELECTRICAL SERVICE</b>	each classroom shall have multiple circuits on breakers not shared with other spaces -- one grounded quadplex 120V receptacle on center of teaching wall -- grounded duplex receptacles spaced around room with at least one on each wall with at least 12 feet apart, all at 18" mounting height refer to OSU wiring standards	each classroom shall have multiple circuits on breakers not shared with other spaces -- one grounded quadplex 120V receptacle on center of teaching wall -- grounded duplex receptacles spaced around room with at least one on each wall and outlets not > 12 feet apart, all at 18" mounting height refer to OSU wiring standards	Electrical service to be coordinated with the Office of Information Technology Classroom Facilities and Systems Design -- Specialized electrical service must be accounted for in A/V systems and Projection Booth Design
<b>B. COMMUNICATION AND DATA TRANSMISSION</b>	refer to OSU wiring standards	refer to OSU wiring standards	refer to OSU wiring standards

PART XI: ROOM ACCESS AND CIRCULATION	SEMINAR ROOMS	GENERAL PURPOSE CLASSROOMS	LECTURE HALLS
<b>A. ROOM LOCATION IN BUILDING</b>	location away from other high student access rooms is encouraged (e.g. libraries, computer labs, departmental offices) shall not be located adjacent to, above, or below toilet rooms, mechanical rooms or elevator shafts	Same as Seminar Rooms -- shall not be located more than three levels above grade -- rooms > 50 capacity shall be located on lower floors -- access from secondary building corridors is discouraged -- clustering classrooms for ease of support services is strongly encouraged	grade or ground floor access is required with preference for exterior ingress to a lobby area outside the Lecture Hall -- convenient access to a building loading dock is preferred
<b>B. ROOM INTERNAL CIRCULATION</b>	unobstructed access to all student seats with a minimum 36" passageway is required	same as Seminar Rooms plus rooms with capacities up to 50 require at least one distribution aisle perpendicular to the teaching wall with two cross aisles row or two distribution aisles with one cross aisle -- rooms > 50 capacity require at least two distribution aisles and two cross aisles directed at doorways -- for fixed seating, aisles between rows must allow minimum 12 inches between rear of seat and raised writing tablet or other furthest protrusion	unobstructed access to all student stations with adequate passage aisles to meet all ADA and Building codes -- multiple distribution aisles
<b>C. DOORS</b>	one access door with a clear glass view panel of 2-1/2" x 17-1/2" required -- door located at rear (opposite end of room from teaching wall) -- all other door characteristics per ADA and Building guidelines	same as Seminar Rooms -- rooms > 49 capacity require two access doors, one at rear and another near center of corridor wall	exit openings as required to meet ADA and Building codes for room capacity -- student access shall be at rear of room for normal ingress/egress pattern -- view panel of 2-1/2" x 17-1/2" required in all exit doors
<b>E. ASSOCIATED ROOMS AND SPACES</b>	classrooms in buildings create demands for nearby waiting space, public-use telephone, and toilet rooms -- however, vending areas shall not be located near classrooms -- waiting spaces shall be design to reduce need for students to sit on floor which interferes with emergency egress	same as Seminar Rooms	same as Seminar Rooms
<b>F. ROOM IDENTIFICATION</b>	provide room number per University signage system	same as Seminar Rooms	same as Seminar Rooms

PART XII: SPACE ALLOCATIONS	SEMINAR ROOMS	GENERAL PURPOSE CLASSROOMS	LECTURE HALLS
<b>A. TEACHING AREA SPACE</b>	Optional due to unusual furniture arrangement -- if a teaching area is defined the minimum depth shall be 6 feet	size of teaching area will vary with room dimensions -- teaching area equals: (depth as specified in Part I-C) x (room width)	depth of teaching area dependent on stage dimensions and location of any fixed equipment such as demonstration bench or electronic lectern; general minimum = (15 feet) x (stage width)
<b>B. AREA PER STUDENT STATION</b>	total room area shall approximate 25 sq. ft. per student station	Seating area = (total room space) - (teaching area) Area per student station = (seating area) / 13 for movable tab-arm chairs, and (seating area) / 17 for movable tables and chairs	Seating area per student station will vary with seating type and arrangement -- typical range from 9-13 sq .ft. per station for fixed tab-arm chairs, 14-17 sq. ft. per station for fixed tables and moveable chairs -- adhere to all ADA and Building design standards for number and width of aisles

PART XIII: CLASSROOM SERVICE ROOMS	SEMINAR ROOMS	GENERAL PURPOSE CLASSROOMS	LECTURE HALLS
<b>A. AUDIO/VISUAL AND COMPUTER EQUIPMENT STORAGE ROOM</b>	provide one 10' x 10' lockable closet with hallway access for up to 10 classrooms in a building -- in buildings with more than 10 classrooms provide one additional storage closet for each additional lot or fraction of 10 classrooms	same as Seminar Rooms -- additional storage may be required within classrooms equipped with video/data projection -- coordinate with the Office of Information Technology Classroom Facilities and Systems Design	separate lockable room, accessible from front of classroom and located adjacent to teaching area -- minimum room size to be 8' x 10' to house carted and installed computers, A/V and video equipment -- room to have two 120 VAC quad outlet boxes and approximately 30 foot candles of illumination -- room is to be heated and air conditioned as per building system
<b>B. PROJECTION BOOTH</b>	optional	optional	projection booth required in all Lecture Halls -- minimum requirements are HVAC ventilation, dimmable lighting and control, 2'Hx 8'W projection window, and a window width countertop with upper surface level with bottom of window -- dedicated circuit with quad electrical receptacle under countertop, two dedicated 20A circuits for audio rack equipment -- exact layout and design to be determined by project through the Office of Information Technology Classroom Facilities and Systems Design
<b>C. PREPARATION ROOM</b>	optional	Optional -- Per special departmental requests and not as a general requirement	Optional -- Per special departmental requests and not as a general requirement

## **APPENDIX P**

2006 Edition, Published January 1, 2006; Document Revision Date: July 1, 2001

---

### **WALKWAY POLICY - THE OHIO STATE UNIVERSITY**

With the volume of physical projects generally underway on the various campuses of The Ohio State University, including new and renovated buildings and their sites, new or modified streets and roadways, underground utilities, open space development, and other landscape improvements, as well as periodic walkway maintenance and repair projects, campus walkways are continually being constructed, replaced or repaired.

A general policy is needed to insure that a continuity of design exists in the development of the pedestrian circulation system on the campuses and to effect economies in the long-term maintenance of that network. Further, the policy should take into consideration the specific character of defined areas or regions of the campuses and recognize the unique purposes for various projects that include or result in walkway construction.

**POLICY STATEMENT:** It is the policy of The Ohio State University that, absent other considerations, the walkways of the University shall be of concrete construction. Pavers, such as pressed brick masonry units or interlocking pavers, may be used as adjunct surfaces for those areas where it is appropriate, to provide for improved drainage, to protect the viability of plant materials, or for design purposes. The use of pavers shall especially be avoided on sloping walks or drives.

**EXCEPTIONS:** Deviations from the policy above shall be permitted in those areas where a predominant character has already been established for walkways by use of other materials.

Deviations from the policy shall also be permitted in especially-defined areas (field areas, gardens, natural areas, special feature sites, etc.) where the use of concrete walkways or masonry pavers would clearly be inappropriate or where structural considerations apply.

The campuses of the institution serve as outdoor teaching laboratories for many disciplines, among which are the School of Natural Resources, the Departments of Architecture, Landscape Architecture, City and Regional Planning, Agricultural Engineering, Horticulture, Botany, Industrial Design, Civil Engineering, the Cooperative Extension Service and others. Deviations from the policy shall be permitted in defined campus areas in support of the academic mission of the University when they contribute to the student's learning environment.

**REQUIREMENTS:** Nothing in this policy shall be construed to mean that all other University standards and requirements shall not be observed in projects involving walkways on the campuses of The Ohio State University. Accessibility, safety, quality of construction and maintenance considerations are not altered by this policy and its exceptions.

---

END OF APPENDIX P

## **Tree Grading Standard: The Ohio State University**

### Introduction:

Because of the extensive ongoing planting due to construction of new and renovated buildings and greenspaces the Campus Tree committee felt it necessary to produce a document that will aid in the beautification of campus, increase the longevity of trees, reduce tree care costs, and could be used by consultants in selection of trees for campus grounds. This document explains the grade of trees expected for all trees planted on campus. The Ohio State University requires trees to be planted on campus to be graded as Florida Fancy or Florida #1.

The Florida Grades and Standards, which this document is based on, is a result of years of cooperation between the Florida Nursery and Landscape Association, private local growers/nurseries, and Dr. Ed Gilman of the University of Florida in Gainesville, FL. The State of Florida's Nursery Grades and Standards document will be adopted for The Ohio State University using pertinent species appropriate for the state. The terms "Florida Fancy", "Florida #1", "Florida #2" and "Cull" will be utilized to describe the grade class designations for consistency with the original system. The included examples have been adapted to Ohio species and the tree list has been updated to reflect what is most commonly grown in nurseries readily available to OSU. All images and most text in this document have been taken directly from the Florida Grading System and changed to reflect Ohio's nursery trees.

This grading system is meant to be used while tagging field trees or selecting trees from ones already dug. The Balled and Burlap (B&B) questions are obviously after harvest and may be ignored when grading trees in the field. After several uses the Worksheet at the end of the text should be sufficient to grade trees in the field or nursery holding yard.

Since most trees have a life expectancy of many years, it is important to plant good quality trees. The quality or grade of a tree at planting can have a huge impact on longevity in the landscape. Tree quality is based on trunk, branch, crown, leaf and root characteristics.

Large-maturing trees which are allowed to develop a double or multiple trunks should not be planted unless it is their habit (i.e. (birch) *Betula spp.*) These are sturdy when young, but could become increasingly hazardous as they grow larger and older. Except for small maturing trees normally grown with multiply trunks, such as; Amelanchier spp (serviceberry), Aesculus parviflora (bottlebrush buckeye) and other nursery trees should have one trunk up through the center to the top of the tree. Some trees can be grown with a modified dominant leader as shown in Figure 1 on page 7 Florida Fancy. Branch diameter should not be larger than 2/3 the diameter of the trunk measured directly above the branch. There should be no flush cuts anywhere on the tree and no open injuries on the trunk or major branches. The crown should be full of foliage and show little, if any, evidence of chlorosis, necrosis, disease or insect infestations. The root ball should be appropriately sized (see any matrix, e.g., page 13),

such a tree is given top grade—**Florida Fancy**.

Trees graded **Florida #1** may require some corrective pruning so they develop good trunk and branch structure. They may have minor trunk injuries or could have other defects. Defects can be corrected by pruning the tree once or twice within a year or two after planting. **Florida #2** is a lesser grade. These trees require major corrective pruning to form a structurally strong tree, or are badly misshapen. Great skill and effort (two or more prunings) are required to develop a structure in these trees which will promote longevity. Defects may take several years to correct.

The lowest grade is a **Cull**. Defects are not correctable. These trees lack vigor and/or have poor trunk and branch structure or circling roots. They have other problems such as open wounds, flush cut or loose root ball which may prevent them from becoming established in the landscape. If they become established, long life is unlikely.

The better grades of trees will require less pruning after planting and they will establish more quickly. These have been properly trained and pruned in the nursery to develop a structure which will be resistant to damage from winds and other outside forces. Most tree maintenance budgets have not been developed to allow for the pruning of a tree after planting, so it makes sense to start with a tree which is healthy and well formed. If there is a large tree-pruning allocation in the landscape maintenance budget, trees with the poorer grades may be trained into sturdy trees in the landscape by skilled arborists.

**Special Note: There is a specialty market for trees trained into forms which are not typical of their normal growth habit. Examples include standards, braided stems, poodles, espalier, topiary and bonsai to name a few. When grading these trees, the height, spread and root-ball diameter-to-caliper relationships outlined in the matrices for these grades and standards do not apply. Therefore when grading such trees, enter the grading process outlined below beginning at Step 6, skipping Steps 1 through 5. Large-maturing trees, such as oaks are always graded beginning with Step 1 unless the planting specifications indicate that the trees will be maintained as topiaries or other small, clipped specimens throughout their lives in the landscape.**

**Grades established for trees (Florida Fancy, Florida #1, and Florida #2) do not apply to trees used in wetland mitigation.**

## **STEPS FOR DETERMINING THE GRADE OF A TREE:**

**Skip Step 2 if you are grading conifers, magnolias, bald-cypress and other narrow upright trees**

### **Step 1: Trunk Form**

Look inside the crown of the tree at the trunk form. Grade the tree according to the drawings and captions in Figure 1 (page 7). Trees with one dominate trunk are graded as Florida Fancy. Those with multiple trunks



**APPENDIX Q Tree Grading Standard**

---

are given a lesser grade depending on the extent of the defect. Circle the appropriate grad below based on trunk form only.

**Florida Fancy                      Florida #1                      Florida #2                      Cull**

**Step 2: Branch Arrangement**

Check branch arrangement. Grade the tree according to the drawings and captions in Figure 2 (page 8). Trees with optimum branch arrangement are graded as Florida Fancy. Those with branch arrangement defects are given a lesser grade according to the extent of the defects. Circle the appropriate grade below based on branch arrangement only. **Note: All conifers, magnolias, bald cypress and other narrow, upright trees are exempt from Step 2.**

**Florida Fancy                      Florida #1                      Florida #2                      Cull**

**Step 3: Matrix Type**

Choose the appropriate tree matrix type based on the natural form of the tree as it should appear the nursery see index of trees on pages 30-34 for guidance.

**Appropriate matrix type:** \_\_\_\_\_

**Step 4: Measure Caliper**

**Measure the caliper of the trunk (under 4” measure 6” up from root flare, 4-6” measure at 12” 6 and above 4.5’ off ground).**

**Caliper:** \_\_\_\_\_

**Step 5: Root-ball/container Size**

**Florida Fancy                      Florida #1                      Florida #2                      Cull**

Locate the caliper of the tree in the left column of the appropriate matrix chart chosen in Step 3. Find the container size or root-ball diameter of the plant you are grading and ignore the caliper (see Figure 5 on page 25). A tree must have a spread equal to or larger than the minimum for the grade. Circle the appropriate grade

below based on minimum crown spread only. ). Refer to Matrix 1 page 13; Matrix 2 page 16; Matrix 3 page 19; Matrix 4 page 22.

**Step 6: Crown Uniformity**

Grade the tree according to structural uniformity of the crown (see Figure 3 on page 10). Circle the appropriate grade below based on the structural uniformity only. Skip Step 6 when grading other trees with a naturally irregular canopy.

**Florida  
Fancy**

**Florida  
#1**

**Florida  
#2**

**Cull**

**Step 7: Lowest Grade**

What is the lowest grade determined in Steps 1,2,5 and 6?

Grade \_\_\_\_\_

**Step 8: Considerations**

If two of the following statements are true, reduce the grade determined in Step 8 by one. If more than two of the statements are true, reduce the grade by two. **Note: It takes two true statements to reduce a Florida Fancy to a Florida #1, three, true statements to reduce a Florida Fancy to a Florida #2.**

- T F** The tree with a trunk caliper larger than 1” requires a stake to hold it erect.
  
- T F** The crown is thin and sparsely foliated. Many evergreen and other trees are thin and sparsely foliated in the late winter/early spring just prior to the spring growth flush. Recently dug field-grown trees might also be thin. Do not downgrade for this.
  
- T F** More than 5% of the branches have tip die-back.
  
- T F** Tree height (see Figure 9 on page 28) is shorter than the maximum height specified in the appropriate matrix chart. Small multi-stemmed specialty plants should not be downgraded if they are shorter than the minimum height.
  
- T F** Flush cuts were made when pruning branched from the trunk (see Figure 4 on page 11)
  
- T F** Branch stubs are left beyond the branch collar (see Figure 4 on page 11). A branch stub can be removed and not reduce the grade.

## APPENDIX Q Tree Grading Standard

---

- T F** Open trunk wounds or other bark injury is evident. (Open trunk wounds must be less than 10% of the trunk circumference and less than 2 inches tall on Florida #1 trees. An open pruning scar on the trunk resulting from removing a branch is not considered an open trunk wound.)
- T F** More than the lower 40% of the trunk is free of branches. ( The portion of the lower trunk with shortened, temporary branches is not considered part of the canopy.) **Note: If planting specifications require that a larger portion of the trunk should be clear of branches, do not downgrade.**
- T F** More than 5% of the leaves are chlorotic or more than 5% of the canopy exhibits damage from pests and diseases. **Note: A Florida #1 cannot have more than 10% of the leaves chlorotic or more than 10% of the canopy damaged from pests or diseases.**
- T F** Most leaves are smaller than normal.
- T F** There is bark included between the trunk and a major lateral branch or between main trunks (Figure 8a on page 27).
- T F** Trunks and/or major branches are touching. Secondary branches on major branches may touch each other.

**Grade:** \_\_\_\_\_

The tree is a cull if 1) any or all of the branches are tip pruned. 2) If it has a root greater than 1/10 the diameter of the trunk circling around more than 1/3 of the trunk in the top half of the root ball. Circling roots can be found on the periphery of the root ball or inside the root ball (Figure 6 on page 25). Those inside the root ball result from being in a smaller container when the tree was younger. Circling roots less than 1/3 the trunk diameter can be cut at the point where they begin to circle. Following cutting, the tree is no longer a Cull.

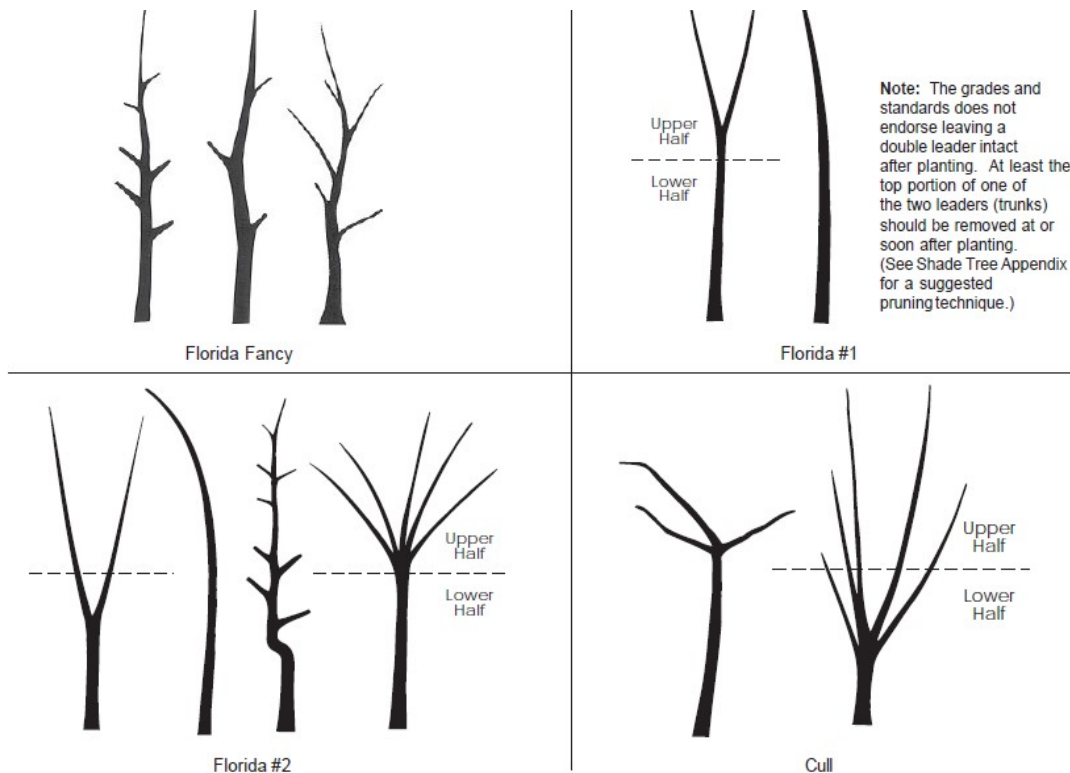
**Final Grade:** \_\_\_\_\_

**Additional Consideration if any are true the tree is a Cull:**

- T F** The root ball or container is undersized (consult proper tree matrix Type I page 13, Type II page 16, Type III page 19, Type IV page 22).
- T F** The root ball on B&B tree is not secured tightly with pins, twine or wire.
- T F** The tree is excessively root-bound.
- T F** There is evidence that one or more large roots (greater than 1/5 the diameter of the trunk) were growing out of the container .
- T F** There is excess soil on top of the root ball (excess soil may be removed to make it acceptable).

**STEP 1—Determining the Quality of Trunk Structure**

**Instructions:** Locate the drawing, caption and associated text below that most closely represents the trunk structure of the tree you are grading. Circle the appropriate tree grade at the end of Step 1 on page 3.



**Figure 1.**

**Florida Fancy**—There is one trunk, more or less in the center of the tree as shown above. It may be straight or have a very slight bow less than 5 degrees. Some trees such as Chinese elm, live oak, and some others can be grown with a modified (not straight) trunk as shown on the right and center. The tip of the leader on the main trunk must be intact and its terminal bud must be the highest part of the tree. No trunk or branch can have a diameter greater than 2/3 the trunk diameter measured directly above the branch crotch. If the trunk divides in two nearly equal-diameter stems in the upper 10% of the tree, the trunk is not downgraded to a Florida #1.

**Florida #1**—The trunk branches (forks) into two nearly equal-diameter trunks in the upper 1/2 of the tree. If one trunk is 2/3 or less than the diameter of the other trunk (they do not have equal diameters) making the trunk Florida Fancy. A noticeable but small void will be left in the crown after removing the top portion of one of the trunks. If there is one trunk, but it has a 5 degree to 15 degree bow, grade it Florida #1. The tip of the leader on the main trunk must be intact and its terminal bud must be the highest part of the tree.

**Florida #2**—The trunk branches into two nearly equal trunks along the lower 1/2 of the tree as shown on the left; or, the trunk branches into three or more nearly equal-diameter trunks in the upper 1/2 of the tree as shown on the right. (Do not downgrade the tree if competing trunks are 2/3 or less the diameter of one main trunk measured above the crotch.) Pruning to create only one trunk will leave a large void in the crown. If there is one trunk, but it has a bow greater than 15 degrees or a dogleg (see Glossary), grade it Florida #2. A dogleg in the crown of the tree is not a downgrading factor.

**Cull**—The trunk branches into three or more nearly equal-diameter trunks along the lower 1/2 of the trunk.

**STEP 2—Determining the Quality of Branch Arrangement**

**Instructions:** Locate the drawing, caption and associated text below that most closely represents the branch structure of the tree you are grading. Circle the appropriate tree grade at the end of Step 2 on page 3. **Note:** All conifers, magnolias, hollies, loblolly bay and other narrow, upright trees are exempt from Step 2. Major branches on trees less than 5 feet tall do not have to be 4" or 6" apart to meet Florida #1 or Florida Fancy standards, respectively.

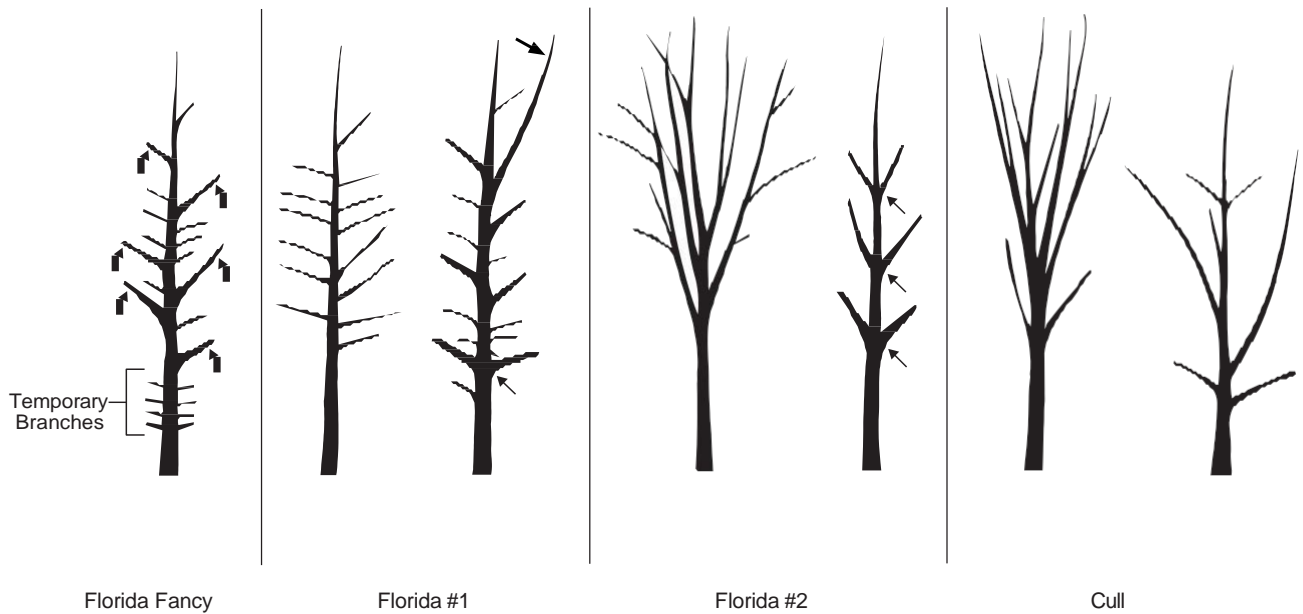


Figure 2

**Florida Fancy**—Several branches are larger in diameter (and obviously more dominant) than others. These (indicated by arrows) should be spaced at least 6" apart along the trunk. No branches are greater than  $\frac{2}{3}$  the diameter of the trunk measured directly above the branch. No major branches are oriented nearly vertical with the trunk. There may be temporary branches on the lower trunk, but these should be no larger than  $\frac{1}{5}$  the diameter of the trunk.

**Florida #1**—All branches are more or less equally dominant as shown in the left illustration; or, as shown in the illustration on the right, there are several dominant major branches but two are nearly equal diameter and less than 4" apart (see arrow at bottom). Other major branches of nearly equal diameter are at least 4" apart. One branch in the upper half of the tree can be greater than  $\frac{2}{3}$  the diameter of the trunk measured directly above the branch. No branch tips are taller than the trunk (see arrow). Note: A number of trees such as bald-cypress, and others with an excurrent (strong dominant leader) growth habit naturally have many lateral branches with a similar diameter. These trees should not be downgraded to Florida #1 due to this growth habit. (See page 3 for trees exempt from step 2.)

**Florida #2**—Most major branches are oriented vertically; and/or nearly equal-diameter major branches are located within 4" of each other at two or more positions on the trunk (see arrows); and/or one or more branches in the lower half of the tree are larger than  $\frac{2}{3}$  the diameter of the trunk measured directly above the branch.

**Cull**—All branches are growing vertically, and they are forming narrow angles with the trunk; or most major branches are growing from the same point on the trunk. Culls may have only a few large branches as in the illustration on the right. Some are less than 4' from the ground. Several branches of nearly equal diameter are opposite each other on the trunk.

**STEP 6 - Determining the Structural Uniformity of the Crown**

**Instructions:** Identify the drawing, caption and associated text below that most closely represents the structural uniformity of the tree you are grading. Circle the appropriate tree grade at the end of Step 6 on page 4.

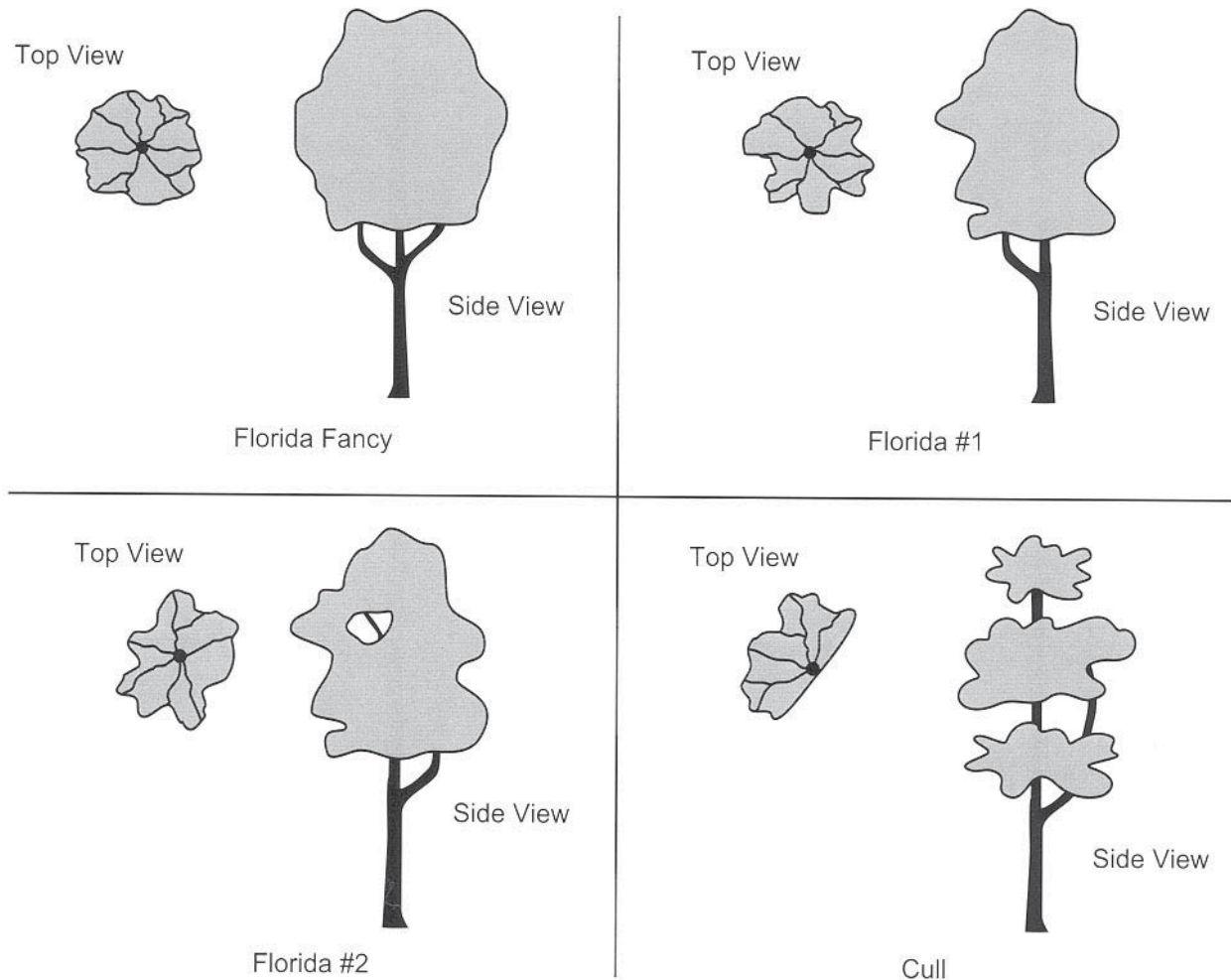


Figure 3.

**Florida Fancy**—Branches are evenly distributed around the trunk. No major branch is located directly above another. The crown is full of foliage which is evenly distributed around the tree.

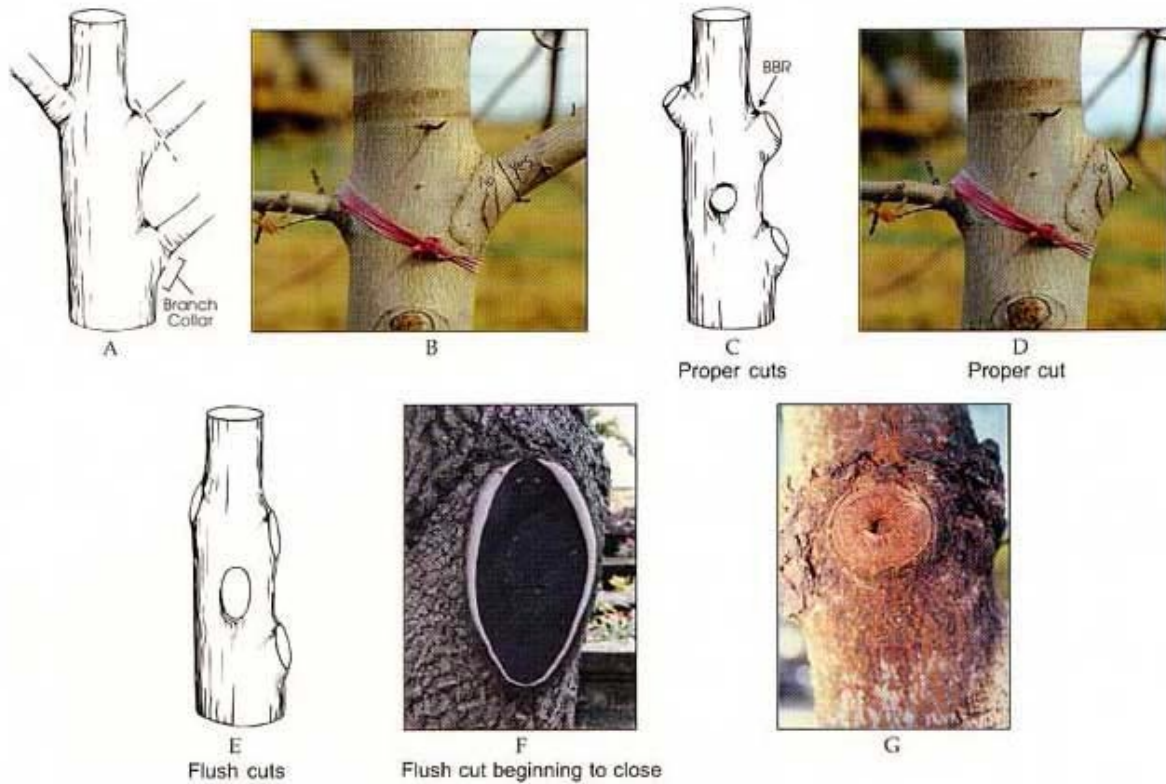
**Florida #1**—One major branch may be located directly above another but the others are nearly evenly distributed around the trunk. The crown is not completely full of foliage and there may be some small voids.

**Florida #2**—Branches are not evenly distributed around the trunk. Several are growing from the same side of the trunk and two or more may be located directly above others. The crown has a large void.

**Cull**—The tree is one-sided or is flat-sided. Major branches are growing from only one or two sides of the trunk. There are large gaps in the crown.

**Step 8 - Determining If Pruning Cuts Were Made Correctly**

**Instructions:** Locate the photograph, drawing, caption and associated text below which most closely represents the condition of the pruning scars on the tree you are grading. Check the 'true' column in Step 9-b if incorrect pruning cuts were made. Check the 'false' column if correct pruning cuts were made, and if there are no trunk injuries.



**Figure 4**

**Fig. 4A**—Notice the swelling at the base of each branch. This is trunk tissue (called the branch collar) and helps hold the branch securely on the trunk. A proper cut is made along the dashed line.

**Fig. 4B**—Cut along the line just to the left of the word 'yes' to properly remove the branch. If the cut is made closer to the trunk, this is a flush cut. If it is made farther from the trunk, a stub will be left.

**Fig. 4C**—This shows how to properly remove branches from the trunk. Always cut to the outside of the branch collar and branch bark ridge (BBR). Notice that the branch bark ridge is still visible on top of the pruning cut and the pruning scar is nearly circular.

**Fig. 4D**—This shows a properly executed pruning cut (right hand side of photograph).

**Fig. 4E**—Never make a flush cut as shown here. Notice that the branch bark ridge is missing from the top of the pruning cut. This improper cut, usually oval, initiates trunk decay and can reduce growth in the nursery and landscape after planting.

**Fig. 4F**—The pruning scar and the woundwood or callus growth which begins to close over the pruning scar from an improperly executed pruning cut is often shaped like an oval. Callus is often missing from the top or bottom of the pruning scar on an improperly executed pruning cut.



**Fig. 4G**—Woundwood or callus growth around a proper pruning cut is circular. Some species have no swelling at the base of branches, and it may be more difficult to determine exactly where to make a proper pruning cut. Always begin the cut to the outside of the branch bark ridge, and angle it away from the trunk.

TYPE ONE MATRIX — SPREADING & ROUNDED SHAPES							
CALIPER	MINIMUM TREE HEIGHT	MAXIMUM TREE HEIGHT	MINIMUM CROWN SPREAD DIAMETER			MINIMUM B&B ROOT-BALL DIAMETER	MINIMUM CONTAINER VOLUME
			FL. FAN.	#1	#2		
1/4"	18"	30"	10"	8"	6"	6"	4" Sleeve
1/2"	24"	6'	14"	12"	8"	8"	1 Gal.
3/4"	4'	8'	30"	24"	18"	14"	3 Gal.
1"	5'	10'	36"	30"	24"	16"	5 Gal.
1 1/4"	6'	11'	42"	36"	30"	18"	7 Gal.
1 1/2"	7'	12'	48"	42"	34"	20"	15 Gal.
2"	8'	15'	54"	48"	42"	24"	15 Gal.
2 1/2"	9'	16'	60"	54"	48"	28"	25 Gal.
3"	10'	18'	66"	60"	54"	33"	45 Gal.
3 1/2"	11'	18'	6'	5 1/2'	5'	38"	65 Gal.
4"	12'	22'	7'	6 1/2'	6'	44"	95 Gal.
4 1/2"	14'	24'	8'	7 1/2'	7'	50"	95 Gal.
5"	16'	26'	10'	9'	8'	55"	95 Gal.
5 1/2"	17'	28'	11'	10'	9'	61"	200 Gal.
<p>Notes:</p> <ol style="list-style-type: none"> <li>1. Trees to be graded under this matrix are listed in the index of trees on pages 29-32.</li> <li>2. Any liner less than 1/4" caliper shall be a minimum of 12" in height, well-rooted in its container which shall not be less than 2" in diameter. Bare-root trees shall be so noted.</li> <li>3. Ball depth on B&amp;B stock shall be at least 2/3 of the root-ball diameter shown. For trees larger than 5 1/2" caliper, root-ball diameter shall be 8.5" for each inch of tree caliper. Trees grown in soils with a high water table can have shallower root balls provided the root-ball diameter is increased to the next larger tree size in the table..</li> <li>4. ANZI Standards Z60.1 designations for container size (e.g. #3, #15, #30, etc.) can be substituted for minimum spread diameter</li> <li>5. NO excess soil above the trunk fair or transport roots is allowed for container or B&amp;B grown plants.</li> </ol>							



Type One Matrix

Spreading and Rounded Shapes

**Florida Fancy**—Branches are well-distributed along a dominant trunk, and the crown is uniform and full of foliage.



**Florida #1**—Branches are well-distributed along a straight dominant trunk, but the crown is not uniform and is thin.



**Florida #2**—The trunk forks in the bottom half of the tree and the canopy is sparse. There are few branches on the tree, and they are not well distributed along the trunk.



Type One Matrix

Spreading and Rounded Shapes

**Florida Fancy**—The trunk has a slight bend which is acceptable for a Florida Fancy on any species.



**Florida #1**—The trunk forks in the top half of the tree



**Florida #2**—The trunk is nicely formed, but the crown is one-sided and not uniform.

TYPE TWO MATRIX — PYRAMIDAL SHAPES							
CALIPER	MINIMUM TREE HEIGHT	MAXIMUM TREE HEIGHT	MINIMUM CROWN SPREAD DIAMETER			MINIMUM B&B ROOT-BALL DIAMETER	MINIMUM CONTAINER VOLUME
			FL. FAN.	#1	#2		
1/4"	18"	30"	10"	8"	6"	6"	4" Sleeve
1/2"	24"	6'	14"	12"	8"	8"	1 Gal.
3/4"	4'	8'	30"	24"	18"	14"	3 Gal.
1"	5'	10'	36"	30"	24"	16"	5 Gal.
1 1/4"	6'	11'	42"	36"	30"	18"	7 Gal.
1 1/2"	7'	12'	48"	42"	34"	20"	15 Gal.
2"	8'	15'	54"	48"	42"	24"	15 Gal.
2 1/2"	9'	16'	60"	54"	48"	28"	25 Gal.
3"	10'	18'	66"	60"	54"	33"	45 Gal.
3 1/2"	11'	18'	6'	5 1/2'	5'	38"	65 Gal.
4"	12'	22'	7'	6 1/2'	6'	44"	95 Gal.
4 1/2"	14'	24'	8'	7 1/2'	7'	50"	95 Gal.
5"	16'	26'	10'	9'	8'	55"	95 Gal.
5 1/2"	17'	28'	11'	10'	9'	61"	200 Gal.
<p>Notes:</p> <ol style="list-style-type: none"> <li>1. Trees to be graded under this matrix are listed in the index of trees on pages 29-32.</li> <li>2. Any liner less than 1/4" caliper shall be a minimum of 12" in height, well-rooted in its container which shall not be less than 2" in diameter. Bare-root trees shall be so noted.</li> <li>3. Ball depth on B&amp;B stock shall be at least 2/3 of the root-ball diameter shown. For trees larger than 5 1/2" caliper, root-ball diameter shall be 8.5" for each inch of tree caliper. Trees grown in soils with a high water table can have shallower root balls provided the root-ball diameter is increased to the next larger tree size in the table..</li> <li>4. ANZI Standards Z60.1 designations for container size (e.g. #3, #15, #30, etc.) can be substituted for minimum spread diameter</li> <li>5. NO excess soil above the trunk fair or transport roots is allowed for container or B&amp;B grown plants.</li> </ol>							



Type Two Matrix

Pyramidal

Shapes

**Florida Fancy**—Branches are well distributed along the single trunk. The crown is uniform and full of foliage.



**Florida #1**—The trunk has a moderate bend or bow, and the crown is not uniform. Either characteristic alone places this tree in the Florida #1 category. The crown is also sparsely foliated.



**Florida #2**—The trunk has a major bend or bow and is sparsely foliated



Type Two Matrix  
Pyramidal Shapes

**Florida Fancy**—There is one straight trunk, branches are well distributed along it, and the crown is full and uniform.



**Florida #1**—The crown is very narrow for this species of tree.



**Florida #2**—There is one trunk, but it has a major dogleg at the bottom of the crown.

TYPE THREE MATRIX — COLUMNAR / UPRIGHT SHAPES							
CALIPER	MINIMUM TREE HEIGHT	MAXIMUM TREE HEIGHT	MINIMUM CROWN SPREAD DIAMETER			MINIMUM B&B ROOT-BALL DIAMETER	MINIMUM CONTAINER VOLUME
			FL. FAN.	#1	#2		
1/4"	18"	30"	10"	8"	6"	6"	4" Sleeve
1/2"	24"	6'	14"	12"	8"	8"	1 Gal.
3/4"	4'	8'	30"	24"	18"	14"	3 Gal.
1"	5'	10'	36"	30"	24"	16"	5 Gal.
1 1/4"	6'	11'	42"	36"	30"	18"	7 Gal.
1 1/2"	7'	12'	48"	42"	34"	20"	15 Gal.
2"	8'	15'	54"	48"	42"	24"	15 Gal.
2 1/2"	9'	16'	60"	54"	48"	28"	25 Gal.
3"	10'	18'	66"	60"	54"	33"	45 Gal.
3 1/2"	11'	18'	6'	5 1/2'	5'	38"	65 Gal.
4"	12'	22'	7'	6 1/2'	6'	44"	95 Gal.
4 1/2"	14'	24'	8'	7 1/2'	7'	50"	95 Gal.
5"	16'	26'	10'	9'	8'	55"	95 Gal.
5 1/2"	17'	28'	11'	10'	9'	61"	200 Gal.

**Notes:**

1. Trees to be graded under this matrix are listed in the index of trees **on pages 29-32.**
2. Any liner less than 1/4" caliper shall be a minimum of 12" in height, well-rooted in its container which shall not be less than 2" in diameter. Bare-root trees shall be so noted.
3. Ball depth on B&B stock shall be at least 2/3 of the root-ball diameter shown. For trees larger than 5 1/2" caliper, root-ball diameter shall be 8.5" for each inch of tree caliper. Trees grown in soils with a high water table can have shallower root balls provided the root-ball diameter is increased to the next larger tree size in the table..
4. ANZI Standards Z60.1 designations for container size (e.g. #3, #15, #30, etc.) can be substituted for minimum spread diameter
5. NO excess soil above the trunk fair or transport roots is allowed for container or B&B grown plants.



Type Three Matrix

Columnar/Upright Shapes

**Florida Fancy**—There is a single trunk, and the crown is full and uniform.



**Florida #1**—There is a single trunk, and the crown is full but not uniform.



**Florida #2**—There is a single trunk, but the crown is thin and not well-balanced.



APPENDIX Q



Type Three Matrix

Columnar/Upright Shapes

**Florida Fancy**—There is one trunk, and the crown is uniform.



**Florida #1**—There is one trunk, and there is a portion of the crown missing, forming an asymmetrical canopy.



**Florida #2**—The crown is very one-sided and asymmetrical.

APPENDIX Q

TYPE FOUR MATRIX — VASE SHAPES							
CALIPER	MINIMUM TREE HEIGHT	MAXIMUM TREE HEIGHT	MINIMUM CROWN SPREAD DIAMETER			MINIMUM B&B ROOT-BALL DIAMETER	MINIMUM CONTAINER VOLUME
			FL. FAN.	#1	#2		
1/4"	18"	30"	10"	8"	6"	6"	4" Sleeve
1/2"	24"	6'	14"	12"	8"	8"	1 Gal.
3/4"	4'	8'	30"	24"	18"	14"	3 Gal.
1"	5'	10'	36"	30"	24"	16"	5 Gal.
1 1/4"	6'	11'	42"	36"	30"	18"	7 Gal.
1 1/2"	7'	12'	48"	42"	34"	20"	15 Gal.
2"	8'	15'	54"	48"	42"	24"	15 Gal.
2 1/2"	9'	16'	60"	54"	48"	28"	25 Gal.
3"	10'	18'	66"	60"	54"	33"	45 Gal.
3 1/2"	11'	18'	6'	5 1/2'	5'	38"	65 Gal.
4"	12'	22'	7'	6 1/2'	6'	44"	95 Gal.
4 1/2"	14'	24'	8'	7 1/2'	7'	50"	95 Gal.
5"	16'	26'	10'	9'	8'	55"	95 Gal.
5 1/2"	17'	28'	11'	10'	9'	61"	200 Gal.

Notes:

1. Trees to be graded under this matrix are listed in the index of trees **on pages 29-32**.
2. Any liner less than 1/4" caliper shall be a minimum of 12" in height, well-rooted in its container which shall not be less than 2" in diameter. Bare-root trees shall be so noted.
3. Ball depth on B&B stock shall be at least 2/3 of the root-ball diameter shown. For trees larger than 5 1/2" caliper, root-ball diameter shall be 8.5" for each inch of tree caliper. Trees grown in soils with a high water table can have shallower root balls provided the root-ball diameter is increased to the next larger tree size in the table..
4. ANZI Standards Z60.1 designations for container size (e.g. #3, #15, #30, etc.) can be substituted for minimum spread diameter
5. NO excess soil above the trunk fair or transport roots is allowed for container or B&B grown plants.

APPENDIX Q



Type Four Matrix

Vase Shapes

**Florida Fancy**—Branches are well-distributed along a single trunk, and the crown is uniform.



**Florida #1**—The crown is uniform, but two major branches in the crown are opposite to each other.



**Florida #2**—The trunk divides into two nearly equal-sized trunks in the lower half of the tree.

## *Tree Terms Glossary*

**Balled and burlapped (B & B):** A soil ball containing roots of the plant wrapped and secured in synthetic, natural or treated burlap, and/or wire. All synthetic fabric (Lenomesh) and wire should be removed from the root ball prior to planting. True biodegradable burlap can be left around the root ball.

**Branch Collar:** The attachment structure in woody plants connects a branch to its parent branch or to the trunk.

**Caliper:** Trunk caliper (trunk diameter) is measured 6 inches from the ground on trees up to and including 4 1/2 inches in caliper, and 12 inches above the ground for larger trees.

**Dominant leader:** The trunk that grows up through the center of the tree and obviously dominates the rest of the branches. A dominant leader originates from a single dominant trunk and is the topmost part of a tree.

**Chlorotic:** A lightness or bleaching (typically yellowing) of green color in the foliage unlike the normal color. This indicates that the plant has not been maintained in the best of health. Chlorotic is not to be confused with normal yellowing of foliage common on many deciduous species late in the season. It is also not to be confused with yellowing of leaves on evergreens just prior to a new leaf flush.

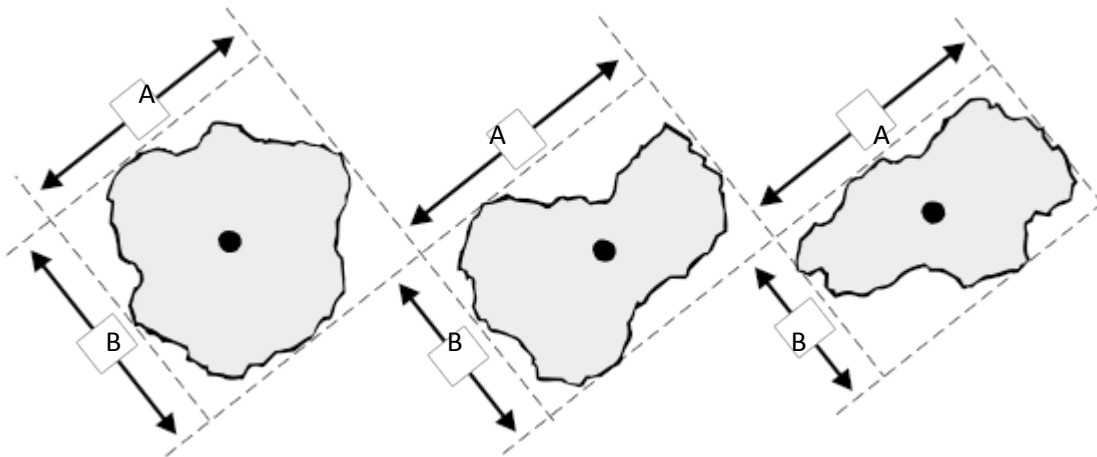
**Clear trunk:** An industry term referring to that portion of the trunk maintained free of any branches. The clear trunk is the lower portion of the trunk measured from the soil line up to the first major branch. Temporary branches may exist on a clear trunk.

**Conifer:** A cone bearing tree such as a fir, spruce or pine. Includes the genera *Abies*, *Picea*, *Pinus*.

**Corrective pruning:** Pruning which removes one or more branches or trunks to create a stronger, well-structured tree framework.

**Crown:** The branches, twigs and leaves that make up the foliage portion of the tree. The above-ground portion of the tree including the branches, twigs and leaves

**Crown spread diameter:** Crown spread diameter is the average of the widest branch spread and that perpendicular to it (see Fig. 5).



**Fig. 5.** Add A and B together and divide by two to obtain crown spread diameter.

## APPENDIX Q

**Cull:** A tree that, as a result of multiple defects (structural and/or health), does not meet the basic standard or specification and is otherwise not acceptable.

**DBH:** Diameter at breast height, which is 4.5 feet of the ground for trees over 6" caliper.

**Excessively root bound:** A condition of container-grown trees where there are several roots larger than 1/4 inch diameter growing on the outside edge of the root ball (see Fig. 6).



**Fig. 6.** Note the circling roots growing along the outside surface of the root ball

**Flush cut:** A pruning cut made too close to, or directly against the trunk. This type of cut is very detrimental to tree health and is not recommended (see Fig. 4 on page 13). It is often difficult to determine whether a flush cut was made 2 or more years after the cut was made on a young tree.

**Grade:** A level of plant quality that meets minimum standards.

**Included bark:** Also referred to as embedded bark. Tree bark growing in contact with tree bark because of the growth of 2 stems (trunks and/or branches) against one another (see Fig. 7a). This typically happens on upright-growing, large-diameter branches which grow at a rate which is similar to the growth rate of the trunk. This branch will be poorly connected to the trunk and could easily break off from the trunk as the tree grows older.



**Fig. 7a.** Example of a weak union illustrating embedded or included bark which is squeezed between the two trunks.



**Fig. 7b.** Example of strong branch union without embedded or included bark. **Note** the dark tissue on the trunk just above the branch crotch. This is the branch bark ridge. Its presence above the branch indicates there is no included bark.

**Leader:** That part of the trunk that extends into the top 1/4 of the tree.

**Major branch:** A branch that is among the largest in diameter on the tree.

**Multiple leaders:** Two or more trunks growing nearly parallel to each other, originating any place along the stem. The crotch angle between them is often very narrow. This tree defect is more serious when it occurs on the lower portion of the tree.

**Nearly-equal diameter:** One trunk or branch is at least 2/3 the diameter of the other. Measure the branch diameter several inches out from the crotch beyond any swelling at the branch base. Measure the larger branch or trunk just above the crotch.

**Necrosis:** dead non-functioning tissue of the foliage

**Root-ball diameter:** The average diameter of the widest portion of the root ball and that perpendicular to it. This shall be measured near the top of the root ball.

**Root crown:** also known as the root collar or root neck (Figure 8), is that part of a root system from which a stem arises. Since roots and stems have quite different vascular anatomies, major vascular changes take place at this point.

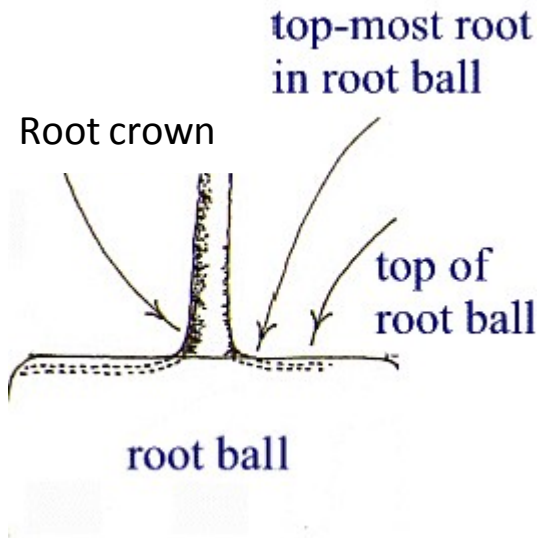


Figure 8

**Secondary branches:** Branches originating from primary or major branches.

**Sturdy in the root ball:** When the trunk bends along its vertical length instead of pivoting at the base of the trunk, or moving in the root ball. When the root ball of a container-grown plant can be slipped from the container with all or most of the media intact with the roots.

**Temporary branches:** Short branches meant to be pruned from the tree in the near future as the tree grows and produces major branches.

**Tree height:** Tree height is measured from the ground to the topmost portion of the tree (see Fig. 9). Height must be measured before pruning the tree. On small, multi-trunked trees, tree height is measured to the top of the main body of the crown.

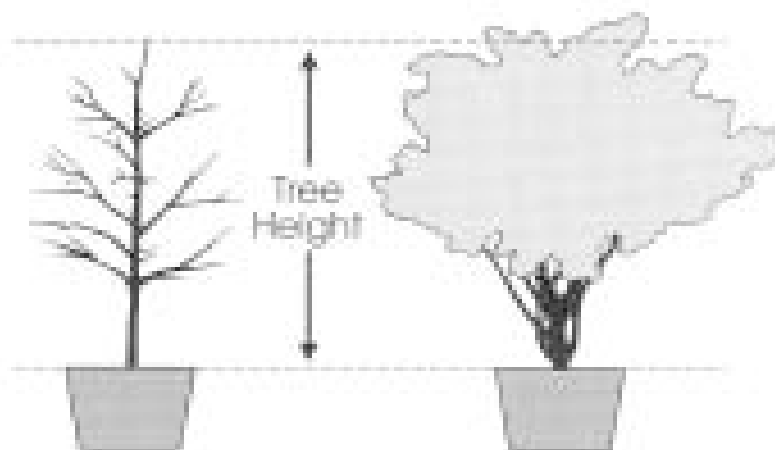
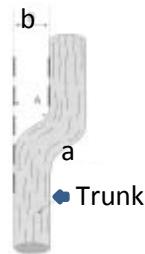


Fig. 9. Measuring tree height

## APPENDIX Q

**Trunk dogleg:** A significant 's' - shaped deformation in the trunk (see Fig. 10). A dogleg in the crown is not a downgrading factor.

**Fig. 10.** The angle 'A' can be no more than 30°. The distance 'B' can be no more than the trunk diameter



**Trunk wound:** A trunk injury that is open and not sealed over, or closed. A properly executed pruning cut that is not closed over is not considered a trunk wound.

**Woundwood :** Woundwood is a very tough, woody tissue that grows behind callus and replaces it in that position. When woundwood closes wounds, then normal wood continues to form. After wounding, callus forms first about the margins of the wound. Woundwood forms later as the cells become lignified. Callus is a tissue that is meristematic, low in lignin, and homogenous as to cell types. Woundwood is not meristematic, is high in lignin, and has differentiated cells -vessels, fibers, axial and radial parenchyma. Woundwood is differentiated tissue that has lots of lignin.



**Table 5.** Matrix or habit rating for trees and other plants in Ohio. Plants are listed alphabetically by scientific name.

Scientific Name	Common Name	Matrix Type
<i>Abies balsamea</i>	Balsam Fir	2
<i>Abies concolor</i> & cultivars	White Fir	2
<i>Acer buergerianum</i>	Trident Maple	1
<i>Acer campestre</i> & cultivars	Hedge Maple	1
<i>Acer xFremannii</i> F	Freeman Maple	1
<i>A.F. Armstrong</i>	Armstrong Fremann Maple	1
<i>Acer ginnala</i> & cultivars	Amur Maple	4
<i>Acer griseum</i> & cultivars	Paperbark Maple	1
<i>Acer japonicum</i> & cultivars	Full Moon Maple	4
<i>Acer negundo</i> & cultivars	Box Elder	1
<i>Acer nigrum</i> & cultivars	Black Maple	1
<i>Acer palmatum</i>	Japanese Maple	4
<i>Acer pensylvanicum</i>	Striped Maple	1
<i>Acer platanoides</i> & cultivars	Norway Maple	1
<i>A.p. Columnare</i>	Upright Norway Maple	3
<i>Acer pseudoplatanus</i> & cultivars	Sycamore Maple	1
<i>Acer rubrum</i> varieties and cultivars	Red Maple	1
<i>Acer saccharinum</i> & cultivars	Silver Maple	1
<i>Acer saccharum</i> & cultivars	Sugar Maple	1
<i>Acer tegmentosum</i> & cultivars	Manchu Striped Maple	1
<i>Acer tataricum</i>	Tatarian Maple	1
<i>Aesculus x carnea</i>	Ruby Red Horsechestnut	1
<i>Aesculus glabra</i>	Ohio Buckeye	1
<i>Aesculus hippocastanum</i> & cultivars	Common Horsechestnut	1
<i>Aesculus octandra</i>	Yellow Buckeye	1
<i>Aesculus parviflora</i>	Bottlebrush Buckeye	1
<i>Aesculus pavia</i>	Red Buckeye	1
<i>Alnus glutinosa</i> & cultivars	Black Alder	1
<i>Amelanchier canadensis</i>	Common Serviceberry	4
<i>Amelanchier x grandiflora</i> & cultivars	Apple Serviceberry	4
<i>Amelanchier laevis</i> & cultivars	Allegheny Serviceberry	4
<i>Aralia spinosa</i>	Devil's Walking Stick	3
<i>Asimina triloba</i>	Pawpaw	1
<i>Betula lenta</i>	Sweet Birch	1
<i>Betula alleghaniensis (lutea)</i>	Yellow Birch	1
<i>Betula nigra</i> & cultivars	River Birch	1
<i>Betula papyrifera</i>	Paper Birch	1
<i>Betula pendula</i> & cultivars	European White Birch	1
<i>Betula populifolia</i> & cultivars	Gray Birch	1
<i>Caragana arborescens</i>	Siberian Peashrub	1
<i>Carpinus betulus</i>	European Hornbeam	1
<i>Carpinus betulus fastigiata</i>	Upright European Hornbeam	2
<i>Carpinus caroliniana</i>	American Hornbeam	1
<i>Carpinus japonica</i>	Japanese Hornbeam	1
<i>Carya</i> (species not listed)	Hickory	1
<i>Carya ovata</i>	Shagbark Hickory	1
<i>Carya illinoensis</i>	Pecan	
<i>Castanea mollissima</i> & cultivars	Chinese Chestnut	1
<i>Catalpa speciosa</i>	Northern Catalpa	1
<i>Cedrus atlantica</i>	Atlas Cedar	2
<i>Celtis laevigata</i>	Sugar Hackberry	1
<i>Celtis occidentalis</i>	Common Hackberry	1

<i>Cercidiphyllum japonicum</i> & cultivars	Katsura Tree	1
<i>Cercis canadensis</i> & cultivars	Redbud	1
<i>Cercis chinensis</i>	Chinese Redbud	1
<i>Chamaecyparis nootkatensis</i> & cultivars	Nootka Falsecypress	2
<i>Chamaecyparis obtusa</i> & cultivars	Hinoki Falsecypress	2
<i>Chamaecyparis pisifera</i> & cultivars	Sawara Falsecypress	2
<i>Chionanthus retusus</i>	Chinese Fringe Tree	1
<i>Chionanthus virginicus</i>	White Fringe Tree	1
<i>Cladrastis kentuckea</i>	American Yellowwood	1
<i>Cornus alternifolia</i>	Pagoda Dogwood	1
<i>Cornus controversa</i>	Giant Dogwood	1
<i>Cornus florida</i> & cultivars	Flowering Dogwood	1
<i>Cornus kousa</i> & cultivars	Kousa/Chinese Dogwood	1
<i>Cornus mas</i> & cultivars	Cornelian Cherry Dogwood	4
<i>Cornus officinalis</i>	Japanese Cornel	4
<i>Cornus racemosa</i>	Gray Dogwood	1
<i>Corylus avellana</i> & cultivars	European Hazel	1
<i>Corylus colurna</i>	Turkish Hazel	1
<i>Corylus maxima</i> & cultivars	Giant Filbert	4
<i>Crataegus crus-galli</i> & cvs	Cockspur Hawthorn	4
<i>Crataegus phaenopyrum</i>	Washington Hawthorn	4
<i>Crataegus species</i> & cultivars	Hawthorn	4
<i>Crataegus viridis</i> & cultivars	Green Hawthorn	4
<i>Diospyros virginiana</i>	Common Persimmon	1
<i>Elaeagnus angustifolia</i>	Russian Olive	4
<i>Elaeagnus umbellata</i>	Autumn Olive / Elaeagnus	1
<i>Eleutherococcus (Acanthopana) sieboldianus</i>	Five-leafed Aralia	4
<i>Eucommia ulmoides</i>	Hardy Rubber tree	1
<i>Euonymus alata</i>	Burningbush	4
<i>Euonymus atropurpurea</i>	Wahoo Euonymus	4
<i>Euonymus bungeana</i>	Winterberry Euonymus	1
<i>Euonymus europaea</i>	European Spindletree	1
<i>Evodia daniellii</i>	Korean Evodia	1
<i>Fagus grandifolia</i>	American Beech	1
<i>Fagus sylvatica</i> & cultivars	European Beech	1
<i>Franklinia alatomaha</i>	Franklin Tree	1
<i>Ginkgo biloba</i> & cultivars	Ginkgo	1
<i>Gleditsia triacanthos (armed)</i>	Common Honeylocust	1
<i>Gleditsia triacanthos (thornless)</i>	Thornless Honeylocust	1
<i>Gymnocladus dioica</i>	Kentucky Coffeetree	1
<i>Halesia carolina</i>	Carolina Silverbell	1
<i>Hamamelis x intermedia</i> & cultivars	Hybrid Witch Hazel	1
<i>Hamamelis japonica</i> & cvs	Japanese Witch Hazel	1
<i>Hamamelis mollis</i>	Chinese Witch Hazel	1
<i>Hamamelis vernalis</i>	Vernal Witch Hazel	4
<i>Hamamelis virginiana</i>	Common Witch Hazel	4
<i>Hydrangea paniculata grandiflora</i>	Pee Gee Hydrangea	1
<i>Ilex decidua</i>	Possumhaw	1
<i>Ilex opaca</i>	American Holly	3
<i>Ilex pedunculosa</i>	Longstalk Holly	1
<i>Ilex verticillata</i>	Winterberry	4
<i>Juglans cinerea</i>	Butternut	1
<i>Juglans nigra</i>	Black Walnut	1
<i>Juglans regia</i>	English Walnut	1
<i>Juniperus chinensis</i> & cultivars	Chinese Juniper	2
<i>Juniperus communis</i>	Common Juniper	2

<i>Juniperus scopulorum</i> & cultivars	Rocky Mountain Juniper	2
<i>Juniperus virginiana</i> & cultivars	Eastern Redcedar	2
<i>Kalopanax pictus</i>	Kalopanax, Castor Aralia	1
<i>Koelreuteria paniculata</i> & cultivars	Golden Raintree	4
<i>Kolkwitzia amabilis</i>	Beauty Bush	4
<i>Laburnum</i> species & cultivars	Golden-chain Tree	1
<i>Larix decidua</i> & cultivars	European Larch	2
<i>Larix laricina</i>	American Larch, Tamarack	2
<i>Ligustrum</i> species	Privet	1
<i>Liquidambar styraciflua</i> & cultivars	American Sweetgum	2
<i>Liriodendron tulipifera</i> & cultivars	Tulip Tree, Yellow Poplar	2
<i>Maackia</i> species	Maackia	1
<i>Maclura pomifera</i> & cultivars	Osage-Orange	4
<i>Magnolia acuminata</i> & cultivars	Cucumbertree	2
<i>Magnolia grandiflora</i> & cultivars	Southern Magnolia	2
<i>Magnolia kobus</i> & cultivars	Kobus Magnolia	1
<i>Magnolia x loebneri</i> & cultivars	Loebner Magnolia	2
<i>Magnolia macrophylla</i>	Bigleaf Magnolia	1
<i>Magnolia quinquepetala</i> & cultivars	Lily Magnolia	1
<i>Magnolia x soulangeana</i> & cultivars	Saucer Magnolia	1
<i>Magnolia stellata</i> & cultivars	Star Magnolia	1
<i>Magnolia tripetala</i>	Umbrella Magnolia	1
<i>Magnolia virginiana</i> & cultivars	Sweetbay	1
<i>Malus</i> species, varieties & cultivars	Flowering Crabapples	4
<i>Malus sylvestris (domestica)</i>	Apple	4
<i>Metasequoia glyptostroboides</i>	Dawn Redwood	2
<i>Nyssa sylvatica</i>	Sour Gum, Tupelo	2
<i>Ostrya virginiana</i>	American Hophornbeam	1
<i>Oxydendrum arboreum</i>	Sorrel Tree, Sourwood	2
<i>Parrotia persica</i>	Persian Parrotia	1
<i>Paulownia tomentosa</i>	Royal Paulownia,	1
<i>Phellodendron amurense</i>	Amur Corktree	4
<i>Photinia villosa</i>	Oriental Photinia	4
<i>Picea abies</i> & cultivars	Norway Spruce	2
<i>Picea glauca</i> varieties & cultivars	White Spruce	2
<i>Picea mariana</i> & cultivars	Black Spruce	2
<i>Picea omorika</i>	Serbian Spruce	2
<i>Picea orientalis</i>	Oriental Spruce	2
<i>Picea pungens</i> & cultivars	Colorado Spruce	2
<i>Pinus banksiana</i>	Jack Pine	4
<i>Pinus bungeana</i>	Lacebark Pine	2
<i>Pinus cembra</i>	Swiss Stone Pine	2
<i>Pinus densiflora</i> & cultivars	Japanese Red Pine	2
<i>Pinus echinata</i>	Shortleaf Pine	2
<i>Pinus flexilis</i>	Limber Pine	3
<i>Pinus monticola</i>	Western White Pine	2
<i>Pinus mugo</i> & cultivars	Mountain Pine	
<i>Pinus nigra</i>	Austrian Pine	2
<i>Pinus parviflora</i> & cultivars	Japanese White Pine	2
<i>Pinus ponderosa</i>	Ponderosa Pine	2
<i>Pinus resinosa</i>	Red Pine	2
<i>Pinus rigida</i>	Pitch Pine	2
<i>Pinus strobus</i> & cultivars	White Pine	2
<i>P.s. fastigiata</i>	Upright White Pine	3
<i>Pinus sylvestris</i> & cultivars	Scotch Pine	2
<i>Pinus thunbergiana (thunbergii)</i>	Japanese Black Pine	2

<i>Pinus virginiana</i>	Virginia Pine	4
<i>Pinus wallichiana (griffithi)</i>	Himalayan Pine	2
<i>Platanus x xacerifolia</i> & cultivars	London Plane	1
<i>Platanus occidentalis</i>	American Sycamore	1
<i>Populus</i> species, varieties & cultivars	Poplar	1
<i>Populus deltoides</i>	Cottonwood	1
<i>Prunus armenica</i>	Apricot	1
<i>Prunus avium</i>	Sweet Cherry	1
<i>Prunus</i> x 'Hally Jolivette'	Hally Jolivette Cherry	4
<i>Prunus x blireiana</i>	Purpleleaf Plum	1
<i>Prunus cerasifera</i> & cultivars	Cherry Plum	1
<i>Prunus persica</i> & cultivars	Peach	4
<i>Prunus padus</i>	European Bird Cherry	1
<i>Prunus serrula</i>	Red-bark Cherry	1
<i>Prunus sargentii</i> & cultivars	Sargent Cherry	1
<i>Prunus serotina</i>	Black Cherry	1
<i>Prunus serrulata</i> & cultivars	Japanese Flowering Cherry	1
<i>Prunus subhirtella</i> & cultivars	Higan Cherry	4
<i>Prunus virginiana</i> 'Shubert'	Shubert Chokecherry	1
<i>Prunus yedoensis</i> & cultivars	Yoshino Cherry	1
<i>Pseudotsuga menziesii</i> & cultivars	Douglas Fir	2
<i>Ptelea trifoliata</i>	Water Ash, Hop Tree	1
<i>Quercus acutissima</i>	Sawtooth Oak	1
<i>Quercus alba</i>	White Oak	1
<i>Quercus bicolor</i>	Swamp White Oak	1
<i>Quercus cerris</i>	Turkey Oak	1
<i>Quercus coccinea</i>	Scarlet Oak	1
<i>Quercus ellipsoidalis</i>	Northern Pin Oak	1
<i>Quercus falcata</i>	Southern Red Oak	1
<i>Quercus ilicifolia</i>	Scrub Oak/Bear Oak	1
<i>Quercus imbricaria</i>	Shingle Oak	1
<i>Quercus laurifolia</i>	Laurel Oak	1
<i>Quercus macrocarpa</i>	Mossycup Oak, Bur Oak	1
<i>Quercus marilandica</i>	Blackjack Oak	1
<i>Quercus Muehlenbergii</i>	Chinquapin Oak	1
<i>Quercus palustris</i>	Pin Oak	1
<i>Quercus petraea</i>	Durmast Oak	1
<i>Quercus phellos</i>	Willow Oak	1
<i>Quercus prinus</i>	Chestnut Oak	1
<i>Quercus robur</i> & cultivars	English Oak	2
<i>Q. r. fastigiata</i>	Upright English Oak	3
<i>Quercus rubra</i>	Northern Red Oak	1
<i>Quercus shumardii</i>	Shumard Red Oak	1
<i>Quercus stellata</i>	Post Oak	1
<i>Quercus variabilis</i>	Oriental Oak	1
<i>Quercus velutina</i>	Black Oak	1
<i>Rhus</i> species & cultivars	Sumac	1
<i>Robinia pseudoacacia</i> & cultivars	Black Locust	1
<i>Salix</i> species, cultivars & varieties	Willow	1
<i>Sassafras albidum</i>	Sassafras	1
<i>Sophora japonicum</i> & cultivars	Japanese Pagodatree	1
<i>Sorbus</i> species & cultivars	Mountain-Ash	1
<i>Stewartia</i> species	Stewartia	1
<i>Styrax japonica</i>	Japanese Snowbell	1
<i>Symplocos paniculata</i>	Asiatic Sweetleaf	1
<i>Syringa</i> species & cultivars	Large Shrub Lilacs	4

<i>Syringa pekinensis</i>	Peking Lilac	1
<i>Syringa reticulata</i>	Japanese Tree Lilac	1
<i>Taxodium distichum</i> & cultivars	Bald Cypress	2
<i>Taxodium distichum nutans (ascendens)</i>	Pond Cypress	2
<i>Taxus cuspidata</i> , Tree forms	Taxus	4
<i>Thuja occidentalis</i> & cultivars	American Arborvitae	2
<i>T. o. fastigiata</i>	Upright American Arborvitae	2
<i>Thuja plicata</i> & cultivars	Giant Arborvitae	2
<i>Tilia americana</i> & cultivars	American Linden, Basswood	1
<i>Tilia cordata</i> & cultivars	Littleleaf European Linden	1
<i>Tilia x euchlora</i>	Crimean Linden	1
<i>Tilia heterophylla</i>	White Linden	1
<i>Tilia mongolica</i>	Mongolian Linden	1
<i>Tilia platyphyllos</i> & cultivars	Large-Leaved Linden	1
<i>Tilia tomentosa</i> & cultivars	Silver Linden	1
<i>Tsuga canadensis</i> & cultivars	Canada Hemlock	2
<i>Tsuga caroliniana</i>	Carolina Hemlock	2
<i>Tsuga diversifolia</i>	Japanese Hemlock	2
<i>Ulmus alata</i>	Winged Elm	1
<i>Ulmus americana</i> & cultivars	American Elm	4
<i>Ulmus carpinifolia</i> & cultivars	Smooth-leaf Elm	1
<i>Ulmus glabra</i> & cultivars	Scotch Elm	1
<i>Ulmus japonica</i>	Japanese Elm	1
<i>Ulmus parvifolia</i> & cultivars	Lacebark Elm	4
<i>Ulmus pumila</i>	Siberian Elm	1
<i>Ulmus rubra</i>	Slippery Elm	1
<i>Ulmus thomasii</i>	Rock Elm	1
<i>Ulmus x</i>	Hybrid Elm	1
<i>Viburnum lentago</i>	Nannyberry	4
<i>Viburnum prunifolium</i>	Black Haw	4
<i>Viburnum rhytidophylloides</i>	Willowwood Viburnum	4
<i>Viburnum rhytidophyllum</i>	Leatherleaf Viburnum	4
<i>Viburnum rufidulum</i>	S Blackhaw Viburnum	4
<i>Viburnum sieboldii</i>	Siebold Viburnum	1
<i>Viburnum x</i>	Hybrid Viburnum	4
<i>Zelkova serrata</i> & cultivars	Japanese Zelkova	4

## STEPS FOR DETERMINING THE GRADE OF A TREE Draft

---

Circle the Appropriate Grad

	ID Tag Number			
<b>Step 1:</b> Trunk Form:	Florida Fancy	Florida #1	Florida #2	Cull
<b>Step 2:</b> Branch Arrangement:	Florida Fancy	Florida #1	Florida #2	Cull
<b>Step 3:</b> Matrix Type:_____				
<b>Step 4:</b> Individual Tree Caliper:_____				
<b>Step 5:</b> Crown Spread:	Florida Fancy	Florida #1	Florida #2	Cull
<b>Step 6:</b> Structural Uniformity:	Florida Fancy	Florida #1	Florida #2	Cull
<b>Step 7:</b> Lowest Grade in Steps 1, 2, 5 and 6_____				

**Step 8:** If two of the Following are true reduce the grade in Step 7 by one. If more than two are true reduce the grade by two:

**T F** The tree with a trunk caliper larger than 1" requires a stake to hold it erect.

**T F** The crown is thin and sparsely foliated. Many evergreen and other trees are thin and sparsely foliated in the late winter/early spring just prior to the spring growth flush. Recently dug field-grown trees might also be thin. Do not downgrade for this.

**T F** More than 5% of the branches have tip die-back.

**T F** A) Tree height is taller than the maximum height specified in the appropriate matrix chart.

**T F** B) Flush cuts were made when pruning branches from the trunk

**T F** C) Branch stubs are left beyond the branch collar. A branch stub can be removed and not reduce the grade.

**T F** D) Open trunk wounds or other bark injury is evident. (Open trunk wounds **must be less than 10% of the trunk circumference** and less than 2 inches tall on Florida #1 trees. An open pruning scar on the trunk resulting from removing a branch is not considered an open trunk wound.)

**T F** F) More than the lower 40% of the trunk is free of branches. (The portion of the lower trunk with shortened, temporary branches is not considered part of the canopy.)

**T F** G) More than 5% of the leaves are chlorotic or more than 5% of the canopy exhibits damage from pests and disease infestations. Reject as Cull if significant or serious.

**T F** H) Most leaves are smaller than normal.

**T F** I) There is bark included between the trunk and a major lateral branch or between main trunks

**T F** J) Trunks and/or major branches are touching. Secondary branches on major branches may touch each other.

**Consider a cull if:** The branches are tip pruned:

**Additional considerations of trees in containers or are already harvested if any are true consider the tree a Cull and do not accept:**

**T F** B) The root ball or container is undersized (consult proper tree matrix).

**T F** C) The root ball on B&B tree is not secured tightly with pins, twine or wire.

**T F** D) The tree is excessively root-bound.

**T F** E) There is evidence that one or more large roots (greater than 1/5 the diameter of the trunk) were growing out of the container.

**T F** F) Does it have a root larger than 1/10 the diameter of the trunk circling 1/3 of the root ball.

**Final Grade:**\_\_\_\_\_

## **APPENDIX R**

2006 Edition, Published January 1, 2006; Document Revision Date: June 30, 2016

### **WINDOW AIR CONDITIONER POLICY**

1. Evaluate the circumstances for suitability and consider the use of window air conditioning units only as a last resort. Obtain approval from the University Architect and the University Engineer prior to any window unit installation.
2. Unit shall not protrude beyond the exterior surface of the building. Unit shall be installed in a manner to assure proper condensate drainage and without using the building façade as a surface path (staining potential) to grade level or creating a nuisance or hazard to pedestrians. Installations, whenever possible, should permit winter closing of windows (double hung and single hung type) past the exterior surface of the unit. This will both conserve energy and somewhat discourage improper turn-on at temperatures below 50 degrees F.
3. Install only in lower sash to provide better access for maintenance.
4. Provide a separate electrical circuit for each unit (typically 208 volt). The 208 volt characteristic results in somewhat more efficient use of energy and also acts as a deterrent to theft for use in residential applications.
5. Purchase and install only units which do not have side vents for condenser air exchange (rear vent units are capable of internal mounting so that windows can close past them in winter).
6. Insofar as feasible, standardize with a single manufacturer's units to minimize problems with stocking parts and familiarization of maintenance personnel.
7. Use of combination heat/cool units is prohibited.
8. Purchasing and/or installing a window unit in a University building without proper review and authorization is prohibited.
9. Window air conditioners, when permitted, shall have a 240 volt DPST timer; 0-4 hour for offices; and 0-12 hour for computer rooms and laboratories. Timers are not required for residential applications.

---

END OF APPENDIX R

**APPENDIX T**

2006 Edition, Published January 1, 2006; Document Revision Date: January 1, 2006

SPECIFICATION  
SYSTEM TRAINING  
FOR  
THE OHIO STATE UNIVERSITY  
COLUMBUS, OHIO

The enclosed specification describes the training for the systems, equipment, and services purchased by The Ohio State University, Columbus, Ohio.

- I. Project Name \_\_\_\_\_  
Project Number \_\_\_\_\_

The following training shall be provided:

- II. Contractor shall provide the total number of hours of training as listed below to The Ohio State University staff. The training shall be strictly provided by the OEM (Original Equipment Manufacturer). Training shall be provided independent of and in addition to "start up and check out" of installed systems and equipment. Training shall be provided on-site during normal working hours and scheduled through The Ohio State University, Facilities Operations and Development Training Coordinator at (614) 688-3289.

The OEM's listed below shall provide the corresponding training hours scheduled directly with the university:

	ORIGINAL EQUIPMENT MANUFACTURER	TRAINING HOURS	SUPPORT HOURS
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____
6.	_____	_____	_____
7.	_____	_____	_____
8.	_____	_____	_____

- III. In addition to Item II, each OEM shall provide the hours listed above of labor to be used for miscellaneous support. The OEM shall provide this additional support during the warranty term.

- IV. Contractor and/or OEM shall provide all necessary training materials, including, but not limited too: books, brochures, pamphlets, audio and video tapes, on-site support manuals, logging sheets, and system documentation materials.

END OF APPENDIX T



## APPENDIX U

2006 Edition, Published January 1, 2006; Division Revision Date: January 1, 2006

### The Ohio State University High Pressure Steam System Hot Water Converter and Steam Meter

This document shall serve as a design guideline for building heating water converter and metering systems supplied by high-pressure steam in main campus buildings.

Fundamental operation shall be the generation of heating hot water using Campus Power Plant High Pressure Steam (HPS) at 185 psig superheated to 580°F directly into a shell and tube heat exchanger. Steam to Hot Water Converters shall be sized and rated for 125% of system operating capacity. This will accomplish sub-cooling of condensate below corresponding saturated steam pressure. Condensate system shall be of the closed loop, un-vented, pump-trap combination type. All system components shall be rated for use under the above stated operating conditions. Steam control valve(s) shall be industrial grade, rotary eccentric plug type. Condensate mover shall be a high-pressure steam powered pump. Trap for heating load shall be float and thermostatic type. Traps for drips shall be thermodynamic. A pilot operated back-pressure regulating valve (BPR) shall be incorporated into the steam condensate system to vent flash steam when pressure exceeds 25 psig. Building heating plants shall consist of a minimum of two (2) complete converter systems including controls and isolation valves to allow operation of any combination of pump(s) and converter(s). Examples of converter system sizing are: 67% (2/3) of total building heating requirement supplied by each of two (2) converter systems, 50% (1/2) of total building heating requirement supplied by each of three (3) converter systems.

Various other steam loads such as domestic hot water, humidification, laboratory, and other process loads shall be generated through the use of similar steam to hot water heat exchangers or steam to steam reboilers.

Refer to other sections of the OSU Building Design Standards (BDS) for piping materials and methods.

#### **System Description:** (Refer to piping schematic)

HPS shall extend to vicinity of converter. Double block and bleed valves shall be installed to isolate each converter independent of other equipment or devices. Steam flow to each converter shall be controlled through the use of two (2) control valves in parallel, sized for 25% (1/4) and 75% (3/4) of the system requirement. The 1/4 valve shall be modulated to control converter leaving water temperature. The 3/4 valve shall be incremented open or closed in steps based on position of the 1/4 valve. A temperature sensor shall be installed in the condensate line ahead of the mover. This sensor shall be used in the control scheme to limit condensate temperature by resetting steam control valve position under start-up conditions. A self-contained pilot operated steam control valve shall be installed in a by-pass line to provide minimum heat in the event of a control system failure. Anticipated sizing of this by-pass line and valve shall be for 25% of total system capacity. It shall have a field adjustable set point with a range of 130° F to 170° F.

With the exception of steam control valves and converter shell connections (which shall be flanged), all HPS piping, equipment, and device connections shall be welded.

Closed loop pump/trap combination condensate return systems require a dedicated mover for each converter. Condensate shall flow by gravity into a receiver vessel sized to adequately store volume of condensate generated under design conditions during the pump-out cycle of the mover. The vent line of the mover shall be connected to the top of this receiver. Minimum fill head between bottom of converter shell and top of receiver, and bottom of receiver and top of mover, shall each be eighteen

inches (18"). The BPR Valve shall be connected independently to condensate receiver. BPR valve discharge piping shall extend safely to the outdoors.

**Butterfly Valves (steam):**

PERFORMANCE:

- I. Rotary valves shall have performance characteristics as listed below.
  - A. Service: steam
  - B. Working pressure, max., psig: 300
  - C. Working Temperature, max., 650 deg. F.
- II. Valve shall be rated at full working pressure per API 607 hardseat 4<sup>th</sup> edition. Each constructed valve shall be tested for zero leakage under water at working pressure using air and for watertight operation.

CONSTRUCTION:

- I. Metal seated rotary tight shutoff valve shall be quarter-turn, triple offset type construction with butt-weld ends as detailed below.

Service: steam

1. Installation: Above ground or steam vaults.
  2. Size, in.: As shown on drawing.
  3. Body type: Butt weld rotary valve
    - a) Body material WCB carbon steel.
  4. Seat: Stellite or similar hard surfaced material
    - a) Resilient, non-flexing laminate metal seal composite of stainless steel and graphite retained such that centering movement is permitted.
    - b) Retainer screws and plate will be of stainless steel, nickel or other non-corrosive materials.
    - c) Disk shall be stainless steel or nickel plated carbon steel.
  5. Shaft shall be of single piece construction.
  6. Disk movement relative to shaft rotation shall be triple offset design.
  7. Per ANSI B16.5, 31, 34 construction for body components B31.1, 31.3, ASME sections VIII, IX.
  8. Valves to meet API 607 Rev. 4 standards.
  9. Hardened bearings with bearing seal to be retained in body.
  10. Shaft seal shall be graphite with multiple stud packing gland follower for adjustability utilizing Belleville style washers.
  11. Right angle gear with 2 in. AWWA nut, with loose steel hand wheel or chain wheel attachment, for remote "tee" handle operation, as shown on drawings
- II. Rotary valves for service requiring insulation shall be equipped with stem and stem housing of suitable length to clear insulation.

III. INSTALLATION:

- a. Install rotary valves where indicated on the drawings.

APPROVED MANUFACTURERS:

- I. Adams (300 ANSI carbon steel type MAK)  
II. Vanessa 30,000 series  
III. Fisher

**Steam Control Valve(s):**

Valve Body/Trim -

1. Rotary Eccentric-Plug style control valve
2. WCC carbon steel body material.
3. ANSI 300RF flanged per ASME/ANSI B16.5-1988.
4. Flow characteristics: linear
5. Class IV shutoff classification as defined by ANSI/FCI 70-2-1991.
6. Graphite stem packing.
7. Trim materials to consist of Chromium-plated CF8M (316 SST) Ball, 316 SST/CoCr-A metal seat ring, 440C SST bearings, 316 SST shaft.
8. Powder coat paint on body exterior.

Actuator -

1. Spring and diaphragm style.
2. Fail closed valve action.
3. Molded diaphragm to provide linearity between loading pressure and travel.
4. Actuator size to be determined by vendor.
5. Elastomers to be nitrile for ambient temperatures between -40 to 180 deg. F. and viton for ambient temperatures between 180 and 300 deg. F.
6. Travel scale for full rated valve travel.
7. Spring adjuster for spring tension adjustment.

I/P Positioner -

1. Pneumatic two-stage style with internal zero and span adjustments
2. Independent linearity - +/- 1.0% of output signal span.
3. Hysteresis - 0.5% of span.
4. Cam characteristic - linear.
5. Deadband - 0.3% of input span.
6. Steady state air consumption less than 30 scfh.
7. Output signal to match vendor-determined actuator input signal.

8. Input signal 4-20 ma.
9. Include output and supply gauges.
10. Include supply regulator factory preset to 5 psig above maximum output signal.
11. Positioner and regulator to be factory mounted with standard copper tubing.

APPROVED MANUFACTURERS:

- I. Neles-Jamesbury
- II. Fisher

**Steam to Hot Water Converter(s):**

Steam to Hot Water Converter(s) shall be shell and tube design with steam in the shell and water in the tubes. Converter tubes and tube sheets shall be type 316 Stainless Steel. Shell shall be provided with 300 # flange connections. Shell side shall be rated for 200 psig steam pressure and temperature of 600 degrees F. Tube side shall be rated for 150 psig and temperature of 600 degrees F. Converters shall be sized and rated for 125% of system operating capacity.

**Pressure Powered Condensate Mover**

1. Non-Electric Condensate recovery pumps.
  - 1.1 Provide packaged condensate return unit including support frame. All appropriately sized check valves, shut-off valves, steam valve(s), cycle counter, and gauge glasses shall be pre-installed and ready for operation.
  - 1.2 The unit shall be factory tested as a complete assembly and shall be shipped as a complete assembly.
  - 1.3 Acceptable manufacturers:
    - Watson-McDaniel
    - Spirax-Sarco
    - Spence.
2. Product
  - 2.1 Non-electric condensate pump shall be pressure-powered type sized to meet the actual maximum capacity of the system being drained. Operation shall be controlled by a float operated, snap action mechanism with no external seals or packing, utilizing check valves for flow direction. They shall be of non-cavitating design operating with up to 200 psig at 600°F motive steam, and be capable of handling water at 350°F when pumping from a closed loop, equalized system. All pumps shall incorporate lift or wafer type check valves unless otherwise noted and pumps shall be supplied with a factory fitted, removable insulation cover.
  - 2.2 The pump shall incorporate either a flash receiver, receiver pipe or a factory assembled tank package to allow for flash steam venting in an atmospheric system. Where a package system is used, all interconnecting condensate inlet piping, isolation valves, base, pump(s), and tank shall be completely assembled and ready for operation. The tank package system shall be capable of building entry through a standard 36" doorway.

- 2.3 Closed loop, pressure powered pump/trap combination shall be provided as required on equipment with modulating steam supply and elevated or otherwise pressurized condensate return lines. When the load changes, backpressure due to either elevation, flash or deaerator pressure will at times be above exchanger and trap inlet pressure. A positive pressure differential across the trap must be maintained through an equalized closed loop steam system using steam as the motive pressure. The system drainage assembly shall include reservoir pipe, pump check valves, liquid level sight glass ,and float/thermostatic trap. Trap sizing shall be by manufacturers' recommendation. Conventional method for trap sizing is based on standard pressure drop with a capacity multiplier of five (5).
- 2.4 Pump Body shall be made of cast steel and all mechanism linkage parts shall be made of stainless steel for improved longevity. The check valves shall be stainless steel. A guarded gauge glass shall be included for all applications. All components up to and including the trap shall be rated for operation at 200 psig steam and 600 degrees F.

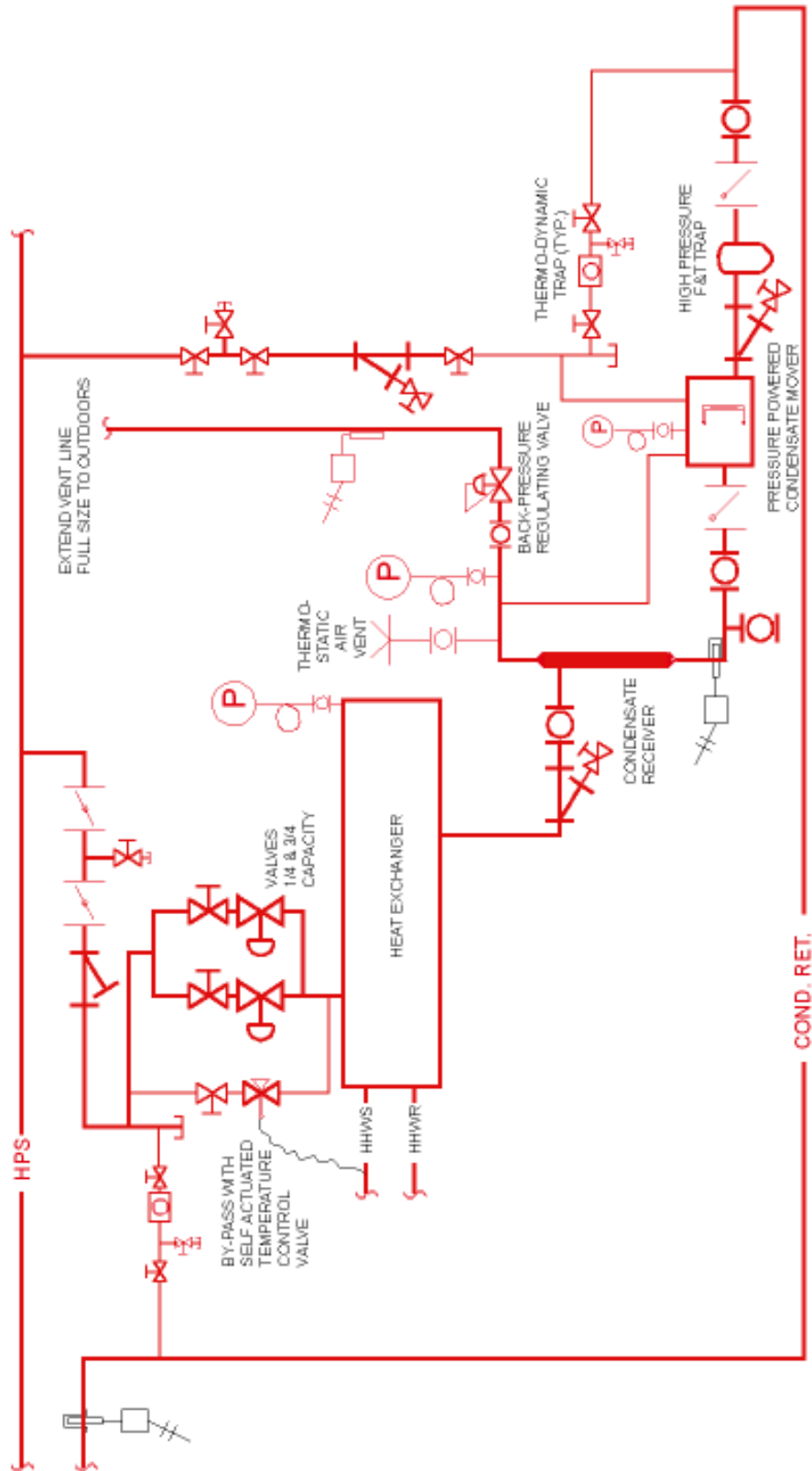
### **High Pressure Steam Flange Connections:**

#### Flange Gaskets:

All flange gaskets used on 200 psig 600 degree F steam components and piping shall be rated for 300 psig 600 degree service. Gasket type shall be concentric corrugated hollow metal core encapsulated with flexible graphite, As manufactured by M&P, Graphonic. Paper or fiber gaskets, though rated 300 psig, are not acceptable.

#### Flange Bolts:

All 200 psig 600 degree steam flange bolts shall be "Grade 8, NC (national course) and shall be installed with a "Anti Seeze" coating on thread surfaces. Bolts shall be tightened following manufacturer's torque and sequence recommendation.



## HIGH PRESSURE STEAM CONVERTER PIPING SCHEMATIC

NO SCALE

## Steam Meter:

### 1. General

#### 1.1 Scope

- A. The main objective of this design standard is to outline the requirements of a steam meter, to measure the consumption of steam supply in total pounds (lbs) in the buildings owned by the Ohio State University, and to communicate this consumption locally and to the campus-wide Energy Metering & Monitoring system. The steam meter shall include the instantaneous mass flow rate in pounds per hour (lbs/hr) and totalized mass consumption in pounds (lbs), with steam pressure and steam temperature compensation.
- B. The steam meter, elements and devices shall be custody transfer measurement. Custody transfer measurement furnishes quantity and quality information which can be used as the basis for a change in ownership and/or a change in responsibility for materials, e.g., billing for rate of energy demand plus totalized energy transfer.
- C. Paragraph 3. Products, describes the general requirements for the totalizing steam meter, primary element, a multivariable transmitter, secondary element, and an RTD temperature sensor/transmitter.

#### 1.2 Submittals

- A. Data sheets, catalog literature, installation instructions, and Operations & Maintenance data must be sent to the Ohio State University Utilities Division for prior review and approval, to include the primary element flow sensor, secondary element(s) (transmitters, multivariable transmitter, etc.), RTD temperature sensor/transmitter, and flow computer.
- B. Interconnections and drawings for installation of the primary, secondary, and tertiary elements of the corresponding devices shall be submitted prior their installation for review and approval.
- C. Certificates for the calculation and conformance of the steam meter according to engineering procedures and practices, and standards, shall be provided. Temperature and pressure compensation, coefficients, linear regressions, constants, equations, methodologies and basis of calculations to establish the steam flow rates shall also be provided for review.
- D. Certificates of calibration for the steam meter with air or any other gas available in the calibration facility, as well as a certificate of calibration conformance for the transmitters in accordance to NIST, U.S. National Institute of Science and Technology.

### 2. Premises for the Selection of the Steam Meter

- 2.1 The selection of the steam meter shall be based on the following parameters and recommendations to guarantee that the accuracy of the steam meter station stays within the  $\pm 1\%$  of the actual reading from 5% to 100% of the maximum rated flow, and the repeatability within  $\pm 0.5\%$ .
  - A. The supply pressure could vary between 120 and 200 psig, whereas the temperature changes between 400 and 660°F.
  - B. The pipe diameter shall be known and shall never be reduced to install the steam meter.

- C. The location of the steam meter shall comply with the straight-run pipes upstream and down stream recommended by the manufacturer.
- D. The mass flow rate shall be computed in lbs/hour, temperature and pressure compensated. The steam meter turndown shall be no less than 30 to 1 based on actual flow conditions.
- E. The pressure drop through the primary element, sensor, shall not be greater than 200 inches w.g.c. for the maximum mass flow rate.
- F. The multivariable transmitter shall provide a 4-20 mA signal for the temperature and pressure compensated mass flow rate in lbs/hour. The flow computer shall totalize the mass flow rate and shall be equipped with a Modbus TCP/IP communications port or other approved remote communications capability. Prior to flow computer approval, the flow computer must be submitted by the Contractor for testing by the Ohio State University Utilities Division to prove interoperability with Utilities Department campus-wide Energy Metering & Monitoring system (Power Management Ion Enterprise).
- G. A remote readout located 5 feet above floor level shall be provided for those cases where the display of the steam meter is more than 6 feet or less than 4 feet above the floor level.

### 3. Products

#### 3.1 Primary Element, Flow Sensor

- A. A Variable Area either non-spring loaded or spring loaded, or an Ultrasonic type sensor shall be used as the primary element of the steam meter. The material of the components of the flow sensor must be 316-stainless-steel or approved material. The nominal size of the sensor shall match the size of the pipe where the flow sensor will be installed. The primary element shall comply with standard codes, ISO, ASME.
- B. For those cases that apply, the flow sensor shall be installed in a wafer or lug type arrangement, constructed of 316 stainless steel, or approved material, rated for 200 psig and 660°F. If the primary flow element is longer than its flange-to-flange dimension, then a spool piece shall be included of sufficient length such as to permit the removal of the primary flow element with spool piece, and eliminate disassembly of any downstream or upstream piping when servicing the element.
- C. Calculations, equations and/or methodology used to determine the size of the flow sensor shall be supplied to the Ohio State University Utilities Division for acceptance. Where applicable, Reynolds number dependent equations shall be checked for maximum and minimum mass flow rates.
- D. Upstream and downstream distances shall be in conformance with the recommendations of the manufacturer, and shall be verified to fulfill the ASME MFC-3M 1989 Ed. or AGA-3 requirements.

#### 3.2 Secondary Element, Transmitter(s), Multivariable Transmitter

- A. The output shall be 4-20mA with digital signal preferable with HART protocol. The accuracy shall be at least  $\pm 0.1\%$  of span, 4 to 20mA, and  $\pm 0.07\%$  of span, digital. Drift less than  $\pm 0.1\%$  of URL over at least 8,000 hours.
- B. Range limits for the differential pressure measurement shall be 0 to 200 inches of H<sub>2</sub>O with a minimum transmitter pressure rating of 300 psi. Range limits for absolute pressure shall be 0 to 300 psia. The transmitter shall be energized with a 24-VDC source or a 120-VAC source for flow computers.



- C. Programming shall be accomplished via a Windows-based software package or from the keypad of the computer flow without the need to open the cover. Thus maintaining the NEMA 4 integrity of the enclosure.
- D. Standard LCD indicator shall be included.
- E. The multivariable transmitter shall provide precise and reliable measurement of absolute and differential pressure, sensor and electronics temperatures, and process temperature from an external RTD. It shall calculate densities, according to Steam Tables ASME 1997, and mass flow rates for the actual pressure and temperature in line.
- F. The process connectors, NPT ¼-inch, shall be 316 stainless steel. A 316 stainless steel 3-valve manifold to mount the transmitter shall be supplied. Drain/vent material and isolation valves shall be also 316 stainless steel and furnished.
- G. The multivariable transmitter shall be supplied with at least 12 feet of AWG-18 shielded twisted pair cable for the RTD input connection.

### 3.3 RTD Temperature Sensor/Transmitter

- A. A spring loaded RTD assembly with transmitter shall be furnished.
- B. The temperature process input range shall be 20 to 800°F.
- C. The thermo-well shall be 316-stainless steel, long enough for the size of the process pipe, and provided with a ¾-inch NPT connection.

## 4. Certifications

### 4.1 Calibration and Calculations

- A. A conformance certificate for the calibration of the steam meter shall be provided.
- B. A certified calculation, for the maximum and minimum mass flow rates at 185 psig and 540°F shall be supplied.
- C. Calibration of the transmitter(s) or multivariable transmitter, shall be accomplished following NIST standards. A certification of conformance shall be submitted.

## 5. Warranty and Operation and Maintenance Manuals

### 5.1 Terms

- A. The supplier/manufacture shall train the Ohio State University Utilities Division personnel to program, calibrate, operate and maintain the above-mentioned devices for at least 3 hours. Training shall be scheduled within two weeks of completion of the installation.
- B. The supplier/manufacture of the above specified equipment shall guarantee for twenty four (24) months from equipment startup or thirty (30) months from date of shipment, whichever occurs first, that the equipment shall be free from defects in design, workmanship or materials.
- C. In the event a component fails to perform as specified or is proven defective in service during the warranty period, the manufacturer shall promptly repair or replace the defective part at no cost (freight, labor at manufacturer facility and parts) to the Ohio State University.
- D. The manufacturer or contractor shall furnish the Ohio State University Utilities Division with an installation, operation and maintenance manual of

the steam meter and all its components. Including the flow computer and a program manual.

6. Inspection

6.1 A representative of the Ohio State University Utilities Division will inspect the installation and performance of the steam meter for acceptance and approval before commissioning.

7. Pre-approved Steam Meter Manufacturers and Models

Spirax/Sarco ILVA flow sensor with Gilflo Steam Flow Computer, including pressure transmitter, temperature sensor and transmitter, differential pressure transmitter and accessories.

McCrometer V-Cone flow sensor with mass flow transmitter and RTD.

GE Panametrics Transient Time Ultrasonic steam flow meter, including flow computer, and pressure and temperature transmitters for flow compensation.

Other models and manufacturers require submittal and pre-approval by The Ohio State University Utilities Division.

---

END OF APPENDIX U

**SAFETY HEALTH & ENVIRONMENT**

- 1.1 ARCHITECT/ENGINEER (A/E) INSTRUCTIONS (Section number 01 35 23 or where the instruction is most applicable)
- A. The first section of this appendix contains instructions to the A/E. The subsequent sections of this appendix contain language which can often (with appropriate revision) be incorporated into the design documents.
1. A Safety, Health and Environment section shall be included in the specification documents for each University project.
  2. Related Sections: Include, but are not limited to, the specification sections that are listed in 1.2.B. Note that individual sections may not be part of every project.
  3. Hazardous Materials: A determination needs to be made by an Asbestos Hazard Evaluation Specialist (AHES) during the design phase of each renovation or demolition project as to whether a hazardous materials assessment is to be required of materials that might be disturbed as a result of the project. There is an asbestos NESHAP requirement that a hazardous materials assessment (including asbestos) must be performed prior to any construction or renovation, especially if this material is known or suspected of being present. EHS can provide advice and assistance with regards to this task. Review specific project needs with the project manager.
  4. Additional Safety Requirements: Notes may need to be added to drawings to highlight special methods of equipment removal and installation. If procedures involve a roof opening, indicate the opening on drawings and specify the need to provide appropriate warning signage, barricades and/or safety railings around the opening to provide for worker safety throughout these procedures.
  5. Crane Safety: Include language regarding crane safety on the appropriate site drawing(s). Show allowable crane locations on the appropriate site drawing(s).
  6. Safety and Health Programs: If work will necessitate refrigerant recovery then the project manager or A/E should contact the appropriate person in Operations to make arrangements to recover the refrigerant.
    - a. Add a drawing note that the contractor is to ensure that there is no escape of refrigerant during removal of existing refrigerant, piping, equipment and during all AC related work. All work is to be done by technicians appropriately certified to handle refrigerants and using equipment registered (if required) with the EPA.
  7. Construction Dust: Identify who will have the on-site responsibility for ensuring that the contractor(s) are doing a good job with respect to housekeeping, dust control, and potential tracking of mud onto the roads.
  8. General Requirements: Show a general note on general demolition or electrical demolition drawings: Unless the fluorescent light bulbs and ballasts are going to be re-used, these items need to be carefully removed and stored for proper disposal as "Universal Waste" as required by the EPA. This would

include all other types of light bulbs such as incandescent, sodium, mercury, etc. These materials cannot be disposed as demolition waste. Contact the Hazardous Waste Supervisor for the Office of Environmental Health and Safety (EH and S) for containers, as well as pickup and disposal arrangements at 614-292-1284. There is no charge for these services; seven days advanced notice is required to schedule with EHS (separate notice for container delivery and also for pickup).

- B. Hazardous Materials Abatement - When abatement is a part of the project, the specification will need sections to address the proper abatement procedures to be followed. Sections are needed to address abatement of asbestos piping insulation, floor tile, drywall mud, lead paint, and any other hazardous materials impacted. These sections need to reference the use of an abatement consultant (usually identified) to provide oversight, review and inspect the abatement work and work procedures and to conduct and/or audit the required clearance sampling. Locations of hazardous materials are to be identified on the appropriate drawings.
- C. Planning for the removal and disposal of equipment (including ductwork) should take into account whether this equipment has been subject to exposure to radioactive, chemical, and/or other hazardous substances.
- D. Evaluate proposed equipment for the potential for noise and vibration generation. Select and specify equipment that generates the least amount of noise and vibration (all other factors being equal).
- E. Locate generator exhaust away, as much as feasible, from building air intakes (from both this project building and also from nearby buildings).
- F. Provide for an eyewash/safety shower in any laboratory or other location, such as a maintenance room or chemical prep room, where chemical exposure potentially occurs. Include in a separate specification when applicable.
  - 1. The eyewash/safety shower needs to be located within 10 second travel distance (approximately 50 ft) of a point of potential accidental exposure to a chemical or biological substance deemed hazardous. This distance will vary depending on the nature of the chemicals that are used. The device should not be obstructed or be located near other hazards such as electrical outlets and panels. The device is to be provided with tepid and/or tempered water as per the latest American National Standards Institute (ANSI) emergency eyewash standard ANSI Z358.1. Drains are required for all eyewashes and safety showers.
- G. Indoor Painting. The followings items should be included in a separate specification when applicable:
  - 1. Restrict, if feasible, indoor painting to those times when the buildings are unoccupied.
  - 2. Paints should be applied using appropriate techniques to reduce the amount of volatiles released to the air.
  - 3. Sufficient amounts of local exhaust ventilation should be employed to keep the build up of odors and toxic compounds within the building to a minimum.
  - 4. Use low-odor paints.

5. Use paints having low volatile organic compounds (VOC's) that meet EPA and consensus industry requirements; substitute water-based products where possible.
  6. Specify compliance with MPI (Master Painters' Institute) standards.
  7. The building occupants should be notified of the scheduled application so they are aware of the work and can make other occupancy arrangements if chemically sensitive.
- H. Design of fixed ladders must meet applicable OSHA requirements (refer to 29CFR1910.27) and ANSI standards.

## SECTION 01 35 23 SAFETY, HEALTH, and ENVIRONMENT

### PART 1 – GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Special Conditions and other Division 01 and 02 Specification Sections, apply to this Section.

#### 1.2 SUMMARY

- A. References: In addition to publications referenced in the Construction Contract Clauses, the following Code of Federal Regulations (CFR) and other publications designate and define hazardous materials and conditions, and establish procedures for handling these materials and conditions. Omission of any publication in this section does not remove any obligation or legal requirement on the part of the contractor to comply with all legal requirements for the location of the work.
1. 29 CFR, Part 1910: Occupational Safety and Health Administration (OSHA) General Industry and Health Standards
  2. 29 CFR, Part 1926: OSHA Construction Industry Standards.
  3. 40 CFR, Part 61: National Emission Standards for Hazardous Air Pollutants.
  4. 40 CFR, Part 261: Environmental Protection Agency (EPA) Characteristics of Hazardous Waste.
  5. 40 CFR, Part 761: EPA Polychlorinated Biphenyls (PCBs), Manufacturing, Processing, Distribution in Commerce and Use Prohibitions
  6. 40 CFR, Part 763: EPA Asbestos.
  7. Federal Standards 313A: Material Safety Data Sheets, Preparation and the Submission of.
  8. NIH DCAB publication "Standards for Temporary Construction," March 1988.
  9. EHS website: The Ohio State University, Office of Environmental Health and Safety. (OSU-EHS) website can be found at <http://www.ehs.osu.edu/>. Various resources are available by clicking on the appropriate tab (e.g. "Occupational Health & Safety").

- B. Related Sections: This specification section is related to any and all specification sections with explicit or implicit reference to cutting and patching. Specific submittal requirements of these related specification sections are not included in this section. Related sections include but are not limited to the following specification sections:
1. Division 01 Section "Summary of Work"
  2. Division 01 Section "Coordination Separate Prime Contracts"
  3. Division 01 Section "Cutting and Patching"
  4. Division 01 Section "Project Meetings"
  5. Division 01 Section "Temporary Facilities"
  6. Division 01 Section "Special Controls"
  7. Division 01 Section "Safety and Health"
  8. Division 02 Section "Asbestos Abatement"
  9. Division 02 Section "Selective Demolition"
- C. Hazardous Materials: Some hazardous and toxic materials and substances are included in 29 CFR Part 1910, subparts H and Z, and in 29 CFR Part 1926 and others additionally defined in Federal Standard 313A. Commonly encountered hazardous materials include but are not limited to asbestos, poly-chlorinated biphenyls (PCBs), mercury, lead sheeting, explosives and radioactive material.
1. Asbestos may be found in spray-on fireproofing, insulation, boiler lagging, pipe coverings, duct insulation, plaster, drywall joint compound, ceiling tile, flooring materials, roofing, and other materials. See Division 02 Section "Asbestos Abatement" for removal requirements.
  2. PCBs may be contained in ballasts, transformers, capacitors, voltage regulators, oil switches, mechanical insulation, caulks/sealants, and other materials.
  3. Mercury can be contained within fluorescent light bulbs, thermometers, thermostats, and other materials.
  4. Lead sheeting can be contained within wall cavities, wall systems, doors and associated components, and other materials.
- D. Acquisition of Publications: Referenced CFR publications may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

### 1.3 SUBMITTALS

- A. Contractor's Safety and Health Program: The contractor shall submit a written copy of the Company Safety and Health Program as well as the site specific safety and health plan for the project to the University Representative within 14 calendar days of the Notice to Proceed or before work commences on the project site, whichever is earlier.
- B. Accident Reports: The Contractor must submit to the University Representative a written report within three calendar days of any accident, fire, emergency, theft or incident in which any personal or property damage took place, regardless of any other notifications performed. Include a copy of each accident report that is submitted by the Contractor or Subcontractors to their insurance carriers, within seven calendar days after the date of the accident.
- C. Material Safety Data Sheets (MSDS): The contractor shall provide the Material Safety Data Sheets (MSDS's) for all products containing hazardous chemicals to the University Representative within 14 calendar days of the Notice to Proceed or before work

commences on the site. The MSDS's shall be maintained at the project site for workers, University personnel and government officials. MSDS's for new products shall similarly be submitted to the University Representative and be retained at the project site until completion of the project.

D.

1.4 PRECONSTRUCTION SAFETY MEETING

A. Prior to commencing construction, representatives of the Contractor, including the general superintendent and one or more safety representatives, shall meet with the University Representative for the purpose of reviewing Contract safety and health requirements.

1. The Contractor's Safety and Health Program and Site Specific Safety and Health Plan shall be reviewed, and implementation of safety and health provisions pertinent to the Work shall be discussed.
2. The Contractor shall be prepared to discuss, in detail, the Contractor's Site Specific Safety and Health Plan including measures intended to control any unsafe or unhealthy conditions associated with the work to be performed under the contract.
3. This meeting may be held in conjunction with the preconstruction conference, if so directed by the University Representative. The conduct of this meeting is not contingent upon a general preconstruction meeting.
4. The level of detail for the safety meeting is dependent upon the nature of the work and the potential inherent hazards
5. Safety meeting shall discuss lockout/tagout procedures. Procedures will be approved by the appropriate University Staff. The "Hazardous Energy (Lock-out.Tagout) Standard" is found at: <http://www.ehs.osu.edu> on the "Occupational Health & Safety" tab.

1.5 COMPLIANCE WITH REGULATIONS

- A. The work, including contact with or handling of hazardous materials, disturbance or dismantling of surfaces containing hazardous materials, and disposal of hazardous materials, shall comply with the applicable requirements of 29 CFR Parts 1910 and 1926, and 40 CFR Parts 61, 261, 761 and 763.
- B. Work involving disturbance or dismantling of asbestos or asbestos containing materials, demolition of structures containing asbestos and removal of asbestos, shall comply with 40 CFR Part 61, Subparts A and M, and 40 CFR Part 763.
- C. Work shall additionally comply with all applicable state and local safety and health regulations.
- D. In case of a conflict between applicable regulations, the more stringent requirements shall apply.
- E. Contractor Responsibility: The Contractor shall assume full responsibility and liability for compliance with all applicable codes, standards and regulations pertaining to the health and safety of personnel during execution of the Work, and shall hold the University harmless for any action on the Contractor's part, or that of the Contractor's employees or subcontractors, that result in illness, injury or death.

1. The Contractor shall have written safety and health programs in compliance with 29 CFR Parts 1910 and 1926.
2. Inspections, Tests, and Reports: The required inspections, tests and reports made by the Contractor, subcontractors, specially trained technicians, equipment manufacturers, and others as required, shall be at the Contractor's expense.

#### 1.6 USE OF POWER ACTUATED FASTENER TOOLS

- A. Use of explosives shall be prohibited.
- B. Power actuated fastener tools are often used on construction sites due to the unique manner in which objects can be accurately and positively secured to a substrate. Also, these tools tend to allow for work to proceed more rapidly and efficiently with desirable results. However, these tools also present potential problems to the work area relative to damaged base material and fasteners. Also, the fastener tools present health and safety hazards to untrained users of fastener equipment, unprotected workers in the immediate work area, as well as building occupants that might be present. Based upon these circumstances, there is a need for safe work practice requirements to be followed whenever such equipment is used. It should be noted that fasteners can be powered or driven primarily by powder charges, gas, or pneumatic means.
- C. Power actuated fastener tools (ex. nail guns, etc.) including pneumatic, powder actuated and gas actuated tools shall not be used or brought to the project site without the permission of the University Representative. Any permission request will include documentation of appropriate training, on-site demonstration, and written standard operating procedures and safety plan for the use of this equipment in the particular application requested.
- D. The contractor must comply with the following in order for the University to grant permission to use the power actuated fastener equipment. The contractor will be fully responsible to every effort to appropriately protect the safety of people and equipment when utilizing this tool. These include, but are not limited to, the following:
  1. The contractor shall inspect the substrate and the fastening material to determine if this proposed fastening method is appropriate. This determination should include a description of the type of material to be fastened and the method of fastening. The base material should be inspected to determine whether it is too hard, soft, or brittle that it may cause spalling, cause the fastener to shatter or not hold, or cause the fastener to free flight.
  2. The contractor shall develop a written description of the work to be performed for the specific University project for which permission has been requested. The contractor shall develop written instructions or procedures on the use of the fastener tool. The standard operating procedures should include the type of surfaces (i.e., metal studs to floor, hangers to the deck, etc.) to be fastened to minimize damage to the building and injury to the user, other employees, and the public and safety precautions. These documents need to be submitted for approval to the University prior to being accepted for use.  
NOTE: Concrete or other surfaces that are damaged shall not be fastened. When fastening into concrete, never fasten closer than two inches from the edge since this may reduce fastener strength or damage to this material.
  3. Trained, competent, and credentialed individuals shall be the only persons allowed to utilize such fastener tools.



4. Individuals will be expected to demonstrate their competency with the University approved fastener equipment prior to being authorized usage on the specific project. This demonstration should be performed in the presence of the University Project Manager and/or a representative from the Office of Environmental Health and Safety.
5. A "Competent Person" shall be present to ensure that the fastener tool is being used properly and workers not involved with the fastener task are clear of the immediate work area. This would include non-construction workers or building occupants above and below where the fastener tool is being used.
6. Fastener tool operators shall report immediately any problems associated with the device or fastener work to the "Competent Person" or immediate supervisor and not proceed until the problem has been resolved and authorization given to proceed.
7. Only the University approved fastener tool shall be used for the specific requested fastening application
8. The contractor shall specify information about the fastener tool(s) to be used on the job. This should include the name of the manufacturer and model number. No other fastener tool can be used without the permission of the University.
9. The fastener tool shall be operated at the lowest power or charge setting, as well as using the shortest fasteners to ensure a sufficient fastening, as well as to minimize personal injury and/or property damage.
10. The fastener equipment should be inspected for proper operation before use to ensure the proper discharge and a solid fastener attachment.
11. The fastener equipment should be unloaded before inspecting, servicing, cleaning or storing.
12. The fastener equipment and charging equipment shall be stored in a tamper resistant container that can be locked when not in use.
13. The fastener equipment shall be used in accordance with the owner's manual and manufacturer's directions.
14. The appropriate personal protective equipment (i.e., safety glasses, hard hats, hearing protection, etc.) shall be worn by the operator of the fastener equipment.

#### 1.7 WORK UNDERGROUND OR IN CONFINED SPACES

- A. Work shall comply with appropriate MSHA (Mine Safety and Health Administration) and OSHA regulations; including but not limited to, 29 CFR 1910.146.
- B. The Contractor shall remove water and debris and properly vent manholes before commencement and during execution of work in manholes.
- C. The Contractor shall have a competent person on site during the project as per the OSHA construction standard.

#### 1.8 ELECTRICAL

- A. Electrical arc welding equipment shall not be connected to the building power supply.

#### 1.9 MATERIAL DELIVERIES

- A. Whenever practicable, deliveries shall be made during regular working hours and only when the Contractor's representative is available to receive them.
  - 1. Deliver material in approved containers and with properly licensed vehicles and operators.
  - 2. Open delivery vehicles are not permitted. Deliver materials in fully closed vehicles or tarp-covered vehicles.
  - 3. All dump trucks shall be fully covered while in transport to and from the unloading site. All loads shall be securely fastened until unloading.
  - 4. Engines shall not be left running while vehicles are loading, unloading, waiting or parked.
  - 5. Do not block roads, walks, building entrances/exits, fire hydrants and standpipes, exterior tanks or building gas connections.
  - 6. Exercise caution regarding all pedestrians and when backing the vehicle.

#### 1.10 HAZARDOUS MATERIAL

- A. The Contractor shall bring to the attention of the Architect/Engineer (A/E) and the University Representative, any material encountered during execution of the Work that the Contractor suspects is hazardous. Work shall be stopped as it relates only to the questioned hazardous material so that the University Representative can - have the Office of Environmental Health and Safety perform tests and/or recommend testing to an accredited third party laboratory, to determine if the material is hazardous before work can be authorized to proceed.
- B. If the tested material is found to be hazardous, and/or if additional protective measures are required, a change to the Contract price may be provided, subject to the applicable provisions of the Contract.

#### 1.11 ADDITIONAL SAFETY REQUIREMENTS

- A. No work shall be performed in any area occupied by the public or OSU employees unless approved by the owner.
  - 1. Accident Treatment and Records: The Contractor shall post emergency first aid information.
  - 2. No person, regardless of position or authority, shall operate any switch, valve, or equipment that has an official lockout/ tagout tag attached to it, nor shall such tag be removed except as provided in this section.
  - 3. When work is to be performed on electrical circuits, the work shall be performed only by qualified personnel following the required safety procedures.
  - 4. Identification markings on building light and power distribution circuit breakers shall not be relied on for establishing safe work conditions.

5. Before clearance will be given on any equipment other than electrical (generally referred to as mechanical apparatus), the apparatus, valves, or systems shall be secured in a passive condition with the appropriate vents, pins, and locks.
6. Pressurized or vacuum systems shall be vented to relieve differential pressure completely.
7. Vent valves shall be lockout/tagout tagged open during the course of the work.
8. Where dangerous gas or fluid systems are involved, or in areas where the environment may be oxygen deficient, systems or areas shall be purged, ventilated, or otherwise made safe prior to entry.
9. Hot Work: If any welding, cutting, or spark generating activity is to be performed, the contractor shall comply with all aspects of OSHA Standard Subpart Q Welding, Cutting and Brazing 29 CFR 1910.252 relating to fire prevention associated with hot work. The contractor shall obtain a hot work permit from the Office of Environmental Health and Safety at; <http://www.ehs.osu.edu> on the "Occupational Health & Safety" tab. The completed hot work permit form needs to be approved by the University Representative. Alternatively, obtain the hot work permit from the Construction Manager for projects on the OSU Medical Center campus.
10. If a roof replacement is to be performed, consideration should be given for the location of the kettles (if any) for the new asphalt roof materials, so as to minimize the potential air contamination problem in adjacent occupied buildings.
11. Crane Safety
  - a. Safety watches shall be used to assess any safety concerns within the swing path of the crane during both the removal /lowering of equipment and also during the lifting /installation of new equipment. A dedicated, full-time safety watch shall be used anytime the crane is in use.
  - b. Particular attention is needed to ensure that spectators and/or other pedestrians are kept clear of the construction site while the crane is in use. Allowable locations for siting the crane are shown on the drawings.
  - c. Daily inspections are required of crane and associated components.
  - d. Comply with all OSHA requirements related to crane operation.

#### 1.12 PERSONNEL PROTECTIVE EQUIPMENT

- A. Special facilities, devices, equipment and similar items used by the Contractor in execution of the work shall comply with 29 CFR, Part 1910, Subpart 1 and other applicable regulations.

#### PART 2 – PRODUCTS

- 2.1 Safety and Health Programs: The Contractor shall submit copies of the written site specific project safety and health plan and emergency action procedures, as applicable to the work scope, as required as a result of the safety meeting, or as required by OSHA 29 CFR, Part 1926 including but not necessarily limited to the procedures and programs that support the requirements of the following:

- A. Designation of Safety Competent Person

- B. Occupational Noise Exposure
  - C. Fall Protection
  - D. Personnel Protective Equipment
  - E. Control of Hazardous Energy
  - F. Hazardous Materials Waste Management Plan (draft if final plan has not been accepted)
  - G. Electrical Safety Related Work Practices
  - H. Lead
  - I. Asbestos
  - J. Refrigerants
  - K. Respirator Protection
  - L. Confined spaces
  - M. Emergency evacuation and reporting
  - N. Hot Work
- 2.2 Contractor's Safety and Health Plan: In addition to specific safety and health programs applicable to the project, Contractor shall submit to the university a copy of the firms' general Safety and Health Plan listing emergency procedures and contact persons with home addresses and telephone numbers.
- 2.3 Permits: If hazardous materials are disposed of off-site, submit copies of shipping manifests and permits from applicable federal, state or local authorities and disposal facilities, and submit certificates that the material has been disposed of in accordance with regulations.
- 2.4 Appropriate lockout/tagout equipment will be provided by the contractor. When required contractor will provide device to allow multiple locks.

### PART 3 – EXECUTION

#### 3.1 EMERGENCY SUSPENSION OF WORK

- A. When the Contractor is notified by the A/E or the University Representative, of non-compliance with the safety or health provisions of the Contract, the Contractor shall immediately, unless otherwise instructed, correct the unsafe or unhealthy condition.
  - 1. If the Contractor fails to comply promptly, all or part of the work will be stopped by notice from the A/E.
  - 2. When, in the opinion of and by notice given by the A/E and or the University Representative, satisfactory corrective action has been taken by the Contractor, work shall resume.
  - 3. The Contractor shall not be allowed any extension of time or compensation for damages in connection with a work stoppage for an unsafe or unhealthy condition.

#### 3.2 PROTECTION OF PERSONNEL

- A. The Contractor shall take all necessary precautions to prevent injury to the public, occupants, or damage to property of others. The public and occupants includes all persons not employed by the Contractor or a subcontractor.
- B. Wherever practical, the work area shall be fenced, barricaded or otherwise blocked off from the public or occupants to prevent unauthorized entry into the work area.
  - 1. Provide traffic barricades and traffic control signage where construction activities occur in vehicular areas.

2. Corridors, aisles, stairways, doors and exit ways shall not be obstructed or used in a manner to encroach upon routes of ingress or egress utilized by the public or occupants, or to present an unsafe or unhealthy condition to the public or occupants.
  3. Store, position and use equipment, tools, materials, scraps and trash in a manner that does not present a hazard to the public or occupants by accidental shifting, ignition or other hazardous activity.
  4. Store and transport refuse and debris in a manner to prevent unsafe and unhealthy conditions for the public and occupants. Cover refuse containers, and remove refuse on a frequent regular basis acceptable to the University Representative. Use tarpaulins or other means to prevent loose transported materials from dropping from trucks.
- C. Construction Dust: Provide measures to prevent the discharge of airborne dust to adjacent properties. Dust potentially will be generated by activities such as site preparation, excavation, trenching, as well as road surface dust from vehicles. Use water spray, temporary enclosures, sweeping and any other methods necessary to minimize or eliminate dust and dirt migration. Comply with governing environmental protection requirements and the requirements of the University (i.e. no visible dust shall be seen leaving the site). If the level of dust or dirt produced is unacceptable to the University all work will be stopped until the situation is corrected. Refer to specification section "Temporary Controls".
- D. Alternate Precautions: When the nature of the work prevents isolation of the work area and the public or building occupants may be in or pass through, under or over the work area, alternate precautions such as the posting of signs, the use of signal persons, the erection of barricades or similar protection around particularly hazardous operations shall be used as appropriate.
- E. Public Thoroughfare: When work is to be performed over a public thoroughfare such as a sidewalk, roadway or other site access way, the thoroughfare shall be closed, if possible, or other precautions taken such as the installation of screens or barricades. When the exposure to heavy falling objects exists, as during the erection of building walls or during demolition, special protection of the type detailed in 29 CFR, Parts 1910 and 1926 shall be provided.

### 3.3 ENVIRONMENTAL PROTECTION

#### A. GENERAL REQUIREMENTS

1. Dispose of solid, liquid and gaseous contaminants in accordance with local codes, laws, ordinances and regulations.
2. The Office of Environmental Health and Safety (EHS) is available to advise on or assist in the collection and disposal of all hazardous waste, excluding asbestos.
3. Comply with applicable federal, state and local noise control laws, ordinances and regulations, including but not limited to 29 CFR, Part 1910.95 and 29 CFR, Part 1926.52.

#### B. SPECIFIC REQUIREMENTS

1. On any project where fluorescent light bulbs and ballasts are removed, unless the fluorescent light bulbs and ballasts are going to be re-used, these items need

to be carefully removed and stored for proper disposal as “Universal Waste” as required by the EPA. This would include all other types of light bulbs such as incandescent, sodium, mercury, etc., as well as contained liquid mercury components retrieved from thermostats and thermometers. These materials cannot be disposed as demolition waste. Contact the Hazardous Waste Supervisor for the Office of Environmental Health and Safety (EH and S) for specific instructions regarding proper storage, to make arrangements to obtain containers, as well as pickup and disposal arrangements. There is no charge for these services; seven days advanced notice is required to schedule with EHS (separate notice for container delivery and also for pickup).

2. If any transformers are to be disposed the presence or absence of PCBs shall be verified, by testing if necessary.
3. During removal or renovation of any system containing chemicals, gases or refrigerants, the appropriate equipment shall be used to capture these substances and prevent their release to the atmosphere. This equipment must be certified as required and be used by properly trained and certified technicians as required by applicable federal, state and local laws and regulations. Proper recordkeeping procedures shall be followed.
4. Containers of volatile sealers, paints, solvents, roofing coatings and other materials should be covered when not in use to prevent the release of volatile organic compounds into the atmosphere. This requirement also applies to the disposal of such products.

---

END OF APPENDIX V

**LABORATORY HOODS, SAFETY CABINETS AND VENTILATION SYSTEMS**

**PART 1 GENERAL**

**1.01 SUMMARY**

A. This standard includes:

1. Laboratory supply air.
2. Laboratory general exhaust, and Laboratory hood, cabinet, and snorkel exhaust.
3. Laboratory animal rooms design criteria.

**1.02 CODES, STANDARDS and REFERENCES**

A. CODES

1. Code of Federal Regulations (CFR)
2. National Electric Code (NEC)
3. Ohio Building Code (OBC)
4. Ohio Revised Code (ORC)

B. STANDARDS and REFERENCES

Use the most current Codes and Standards unless superseded by the Ohio Building Code or Ohio Law. A partial list of applicable standards and codes includes:

1. Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC).
2. American Conference of Governmental Industrial Hygienists (ACGIH), Industrial Ventilation - A Manual for Recommended Practices.
3. American National Standards Institute, American Industrial Hygiene Association, (ANSI/AIHA), National Standard for Laboratory Ventilation.
4. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), Laboratory Design Guide.
5. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), Heating, Ventilating, and Air Conditioning Applications.
6. ASHRAE 110 – Method of Testing Performance of Laboratory Fume Hoods
7. NFPA = NFIPA = National Fire Protection Association, Quincy, MA.
8. NFPA 45, Chapter 6 - Fire Protection for Laboratories Using Chemicals.
9. NFPA 70 - National Electrical Code.

10. NFPA 801, Chapter 5 - Recommended Fire Protection Practice for Facilities Handling Radioactive Materials.
11. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
12. NFPA 91 - Standard for the Installation of Blower and Exhaust Systems.
13. National Research Council (NRC), Guide for the Care and Use of Laboratory Animals, National Academy of Sciences, Washington, D.C.
14. NSF = The National Sanitation Foundation, Ann Arbor, MI.
15. National Sanitation Foundation (NSF) NSF 49 - Standard for Class II (Laminar Flow) Biohazard Cabinetry.
16. Scientific Equipment and Furniture Association (SEFA), Laboratory Fume Hoods Recommended Practices, SEFA 1.2.
17. The Ohio State University (OSU) Building Design Standards (BDS).
18. Institute for Laboratory Animal Research (ILAR)

### 1.03 VENTILATION SYSTEM DESIGN GUIDELINES

- A. The purpose of Laboratory Ventilation Systems is to provide a safe environment to occupants, researchers, teachers, staff, students, visitors, and subjects, and to protect the laboratory and the business investment therein, by controlling and exhausting contaminants and providing acceptable ventilation, while simultaneously minimizing energy and maintenance costs.
  1. The primary means of providing safety and controlling and exhausting contaminants shall be fume hoods (chemical hoods, radiological hoods, perchloric acid hoods, laminar flow hoods, biological safety cabinets (Class II, B2, or B3), glove box (Class III), snorkels, and Laboratory hood exhaust system. .
  2. The secondary means of providing safety and controlling and exhausting contaminants shall be the Laboratory Ventilation Systems. In addition to safety, the Laboratory Ventilation Systems shall also provide comfort control within the room (temperature and, if applicable, humidity control). The Laboratory Ventilation Systems shall include Laboratory supply air, and Laboratory general exhaust.

### 1.04. HOOD PERFORMANCE and DESIGN GUIDELINES

- A. Locate hoods away from air turbulence, egress traffic, operable windows, doors, air supply grilles and heavy traffic aisles.
- B. Constant air volume "Bypass type" Fume Hoods shall not be permitted to be installed in new or renovated facilities unless authorized in writing (e.g. e-mail, etc.) by the University Engineer.



- C. All Fume Hoods shall be variable air volume (VAV) type with vertical sash operation and position hardware. The fume hood shall be provided with a sash stop, set at 18-inches.

**Commentary:** *The intent of this requirement is to allow existing facilities undergoing a “partial” renovation to at least install fume hoods that can have volume control dampers and direct digital controls integrated in the future with the hood sash position hardware.*

1. New facilities or major renovations of laboratory facilities must have fully functional VAV fume hood systems (exhaust air/supply air/ fume hoods) and laboratory room pressure differential control systems or another type of control system that will maintain the proper pressure or supply/exhaust air volume relationship between the laboratory rooms and adjacent rooms.

**Commentary:** *The control methodology suggested above is intended to provide the proper pressure relationships, and thereby air flow direction, between rooms; it is NOT intended to restrict the acceptable manufacturers or vendors of controls or hardware systems that can accomplish this design intent*

- a. All Fume Hoods for these applications shall be provided with automatic sash closure control system. The fume hood exhaust airflow control device must, upon opening the sash, respond to the change in sash position to maintain the proper face velocity within three seconds of the sash reaching its final position.
2. There may be special fume hood applications that require a different design configuration than indicated within this Appendix: these applications should be presented for review by OSU Environmental Health and Safety Department and accepted in writing (e.g. e-mail, etc.) by the University Engineer.
3. All fume hood conceptual designs and applications must be formally reviewed (e.g. e-mail) by OSU Environmental Health and Safety (EHS) Department and the University Engineer. The A/E shall provide documentation showing acceptance of the conceptual design to the OSU Project Manager. The OSU Project Manager shall maintain a record of this fume hood concept documentation.
4. All exhaust air control dampers shall be Normally Open.

**Commentary:** *The intent is to maintain a negative pressure within the lab room relative to adjacent rooms in order to reduce the potential for contamination of the adjacent rooms.*

- D. All newly installed hoods must meet the testing requirements set forth in the National Institutes of Health (NIH) or ASHRAE Standard 110. On Site Testing for Constant Volume Fume Hoods or Variable Air Volume (VAV) Fume Hoods as necessary and in accordance with the latest published testing criteria.

- E. For VAV hoods, tests shall be run at 60, 80 and 100 feet per minute (FPM).

1. The minimum acceptable lab hood face velocity, based on a standard 18-inch vertical opening, shall be 80 feet per minute.

- F. Test results must be submitted to the A/E, OSU Project Manager and OSU Environmental and Occupational Health & Safety for review. Approved hoods will be considered acceptable for use for the specific project application but not necessarily for ALL OSU buildings and laboratories.
- G. Final as-installed field testing will be completed upon installation through a third party, certified to perform the following test(s). As-installed testing shall meet the NIH On Site Testing requirements listed in B of this section. Test results shall be submitted to the OSU Project Manager.

**Commentary:** *This field testing of hoods will normally be assigned to the Commissioning Agent that is contracted directly with the University.*

- H. Chemical fume hoods, auxiliary hoods, canopy hoods, glove boxes, and horizontal flow (clean benches) are not to be permitted without careful review by OSU Environmental and Occupational Health and Safety and approval by the University Engineer.

**Commentary:** *Historical performance and maintenance problems associated with these hood designs plus the selection and proper application necessitates this review and approval process. The A/E has the fiduciary responsibility to provide the University with all the facts related to the selection of equipment chosen and recommended by the A/E*

*In addition to the NIH test and ASHRAE 110 test requirements, a heat load must be placed on the hood during testing. Heat shall be applied to hood using hot plates and temperatures maintained at 90° F (32.2° C) measured 3 feet above working surface of the hood; and 1 foot from back of hood.*

#### 1.05 ENERGY COST CONSIDERATIONS

- A. The Laboratory design, the equipment selections, and the equipment operation must incorporate all considerations to allow operation at the lowest energy costs.

#### 1.06 MAINTENANCE COST CONSIDERATIONS

- A. The Laboratory design, the equipment selections, and the equipment and accessory locations, must incorporate all considerations to facilitate maintenance, and allow maintenance at the lowest costs.

#### 1.07 LAY-IN CEILINGS

- A. Lay-in ceilings should be provided, if feasible for the particular application, in all Laboratory and Laboratory Support spaces which are required to have minimum air changes per hour (ACH's).
- B. Ceiling heights (between finished floor and lay-in ceiling) within these spaces shall be designed and installed realistically as low as possible in order to minimize total ventilation volumes, while maintaining minimum ACH's, and thereby minimize total energy costs. Low ceiling heights may not be acceptable for ALL applications and should be properly addressed and documented by the A/E.

PART 2 PRODUCTS

2.01 LABORATORY VENTILATION SYSTEMS

A. LABORATORY SUPPLY AIR SYSTEMS

1. Laboratory supply air systems shall be capable of containing contaminants below accepted governmental and consensus industrial exposure standards, flammable limits, and noxious chemical odor thresholds.
2. An "Air Change" is defined as introduction of conditioned air to a space. Acceptable "conditioned air" shall be in compliance with ASHRAE Standard 62.1.
3. An "Air Change Rate" (e.g. air changes per hour; aka ACH) is defined as airflow in volume units per hour divided by the building space volume, between the floor and finished ceiling, in identical volume units.
4. The term "Occupied" refers to the presence of humans or animals within the room. The term "Unoccupied" refers to the absence of humans or animals within the room. The A/E must use judgment when applying these terms.
5. Minimum Laboratory Air Change Rates
  - a. Minimum air change rates for laboratories shall be 6 air changes per hour when occupied except where noted below.
  - b. Minimum air change rates for laboratories shall be 4 air changes per hour when unoccupied except where noted below.
  - c. The above are OSU recommended minimum ACH's. The A/E remains responsible to consider and apply the heating and cooling ventilation requirements, the toxicity of the contaminants, hood manufacturer recommendations, all applicable codes, all applicable standards, and all recommended good practices for each application. The associate shall obtain approval from OSU before proceeding with the design.
  - d. The Unoccupied ACH's are applicable only when the ventilation rates can be restored to the Occupied ACH's by the laboratory personnel when working during normally Unoccupied periods such as evenings, weekends, and holidays. The system must incorporate these Occupied and Unoccupied features and selections.
  - e. A visual light indicating device may be located at the entry of each laboratory to show the Occupied/Unoccupied status of the room HVAC system.

**Commentary:** *Other means of indicating the occupancy status of the room may be presented by the A/E; however, consensus must be obtained with the primary stakeholders and the University Engineer.*
6. Special ventilation areas (such as BSL 3 facilities, areas using known carcinogens, animal necropsy, autopsy, nanotechnology, etc) may require a different design configuration than indicated within this appendix: Conceptual designs for these applications should be submitted by the A/E for

review by OSU Environmental Health and Safety and approved in writing by the University Engineer.

7. Animal facilities shall be designed in accordance with the latest requirements found at the Institute for Laboratory Animal Research.
8. Any facility requiring special accreditation shall conform to the latest requirements of the accrediting body.
9. Heating for 100% fresh air shall apply hot water heating, with coil recirculation pump for continuous flow to the coil, modulating internal face-and-bypass damper. If the supply and/or exhaust fans are served by emergency power, then the coil recirculation pump shall also be served by emergency power.

**Commentary:** *The intent of this paragraph is to emphasize that a reliable heating source is usually needed for critical lab applications (e.g. research labs). The A/E needs to be aware of this intent when balancing design concepts and costs and advise the University stakeholders of the benefits and/or consequences of the design concept.*

10. Pressure gradients between rooms and areas shall be obtained by designing and balancing total air volumes at any and all operating conditions:
  - A. Laboratory Rooms shall be maintained at negative pressures, in relation to Laboratory Support Rooms and non-laboratory areas, by total Laboratory exhaust volume being 5% greater than total supply air volume.
  - B. Laboratory Support Rooms shall be maintained at negative pressures, in relation to non-laboratory areas, but at a slightly less negative pressure than Laboratory rooms. The total exhaust volume being 5% greater than total supply air volume.
11. Laboratory room temperatures and humidity levels should be maintained during 'Occupied' and 'Unoccupied' periods in compliance with the OSU Building Design Standards unless the application requires more stringent requirements. The A/E shall obtain approval from the University Engineer for deviations from the Building Design Standards.
12. Laboratory noise levels should be maintained not to exceed Building Design Standard and ASHRAE Handbook HVAC Applications.

**B. LABORATORY EXHAUST SYSTEMS**

1. Laboratory exhaust fans shall be above the roof and readily accessible for maintenance.
2. For manifold exhaust air systems, provide at least N+1 or greater backup exhaust fan capacity, and isolate each exhaust fan, such that one exhaust fan may be stopped and serviced, while simultaneously retaining the full capacity and function of the total exhaust system.

**Commentary:** *"Manifold" refers to combining several points of exhaust needs (e.g. lab hoods) into a common duct or exhaust plenum.*

*This "manifolded" exhaust must then be served by more than one exhaust fan in order to maintain proper exhaust air quantities to the individual hoods or exhaust devices in case one of the exhaust fans fails. The A/E must verify that "manifolding" exhaust ducts is acceptable for the particular application.*

3. All laboratory exhaust ducts shall be at negative pressure with respect the entire interior building envelope. It is prohibited to have any portion of any laboratory exhaust duct to be at any positive pressure with respect to any portion within the building envelope.
4. Laboratory exhaust shall be a vertical stack discharge at the roof of the building; the stack exit velocity shall be 3000 fpm minimum, or greater.
5. Exhaust stacks shall be sufficiently high such as to eject the exhausted contaminants away from the building, and away from all adjacent buildings. Exhausted contaminants shall be ejected in a manner such as to prevent re-entrainment of contaminants into fresh air intakes into the building, or into all adjacent buildings.
6. The exhaust stacks or ducts should be at least 8-feet higher than building elements within 33-feet, including any door, window, intake grille or occupied space.
7. Energy recovery systems should be provided for all laboratory exhausts to pretreat (heat or cool) the supply air for the laboratory. The A/E shall evaluate energy recovery system(s) and obtain approval for type of system(s) from the University Engineer prior to start of design.

**Commentary:** *Currently, air to air or heat wheels are not an acceptable heat recovery system for laboratory applications due to the potential for cross contamination. Coil run-around-loops are an acceptable heat recovery method.*

8. For Animal rooms, all exhaust air grilles shall include 35% pre-filters, nominal 2"-thick, to prevent animal hair and/or dander from accumulating in the exhaust ductwork, and from accumulating in the fan(s). The preferred design location for exhaust and return grilles is 18" above the floor.
9. For Animal rooms, where wash-down of the room is required, sensors for temperature control, humidity control, and lighting shall be located such as to never have water or water mist impacting on the sensor or transducer or transmitter.
10. Discuss, with the Project Manager, the need or desirability of exhaust systems being on standby or emergency power during the design process.

C. EXHAUST AIR DUCTWORK CONSTRUCTION

1. Materials for the Laboratory exhaust system shall be non-combustible. Suggested materials are:
  - a. Radioisotope or bacteriological: stainless steel.

- b. General chemical exhaust: carbon steel sandblasted and coated with epoxy or coated with a phenolic.
- c. Perchloric acid: Type 316 stainless steel or rigid PVC, and inorganic ceramic coating.

**Commentary:** *PVC coated ductwork is not an acceptable composite. The choice of duct material for the particular application is the responsibility of the A/E and must be in compliance with NFPA 45.*

- 2. Fire dampers are prohibited in hood exhaust ducts, unless specified otherwise by local codes and approved by the University Engineer.
- 3. An interlocking arrangement to shut off laboratory exhaust fan, if laboratory supply fan fails, is prohibited.
- 4. Fire detectors and alarm devices shall not automatically shut off laboratory exhaust fans, except as required when actuating a fluorocarbon or carbon dioxide extinguishing system.

**Commentary:** *The maintenance of the exhaust pre-filter will normally be provided by the Using Department. The OSU Project Manager must communicate and document this requirement to the Using Department and OSU Operations.*

## 2.02. LABORATORY HOODS

### A. CEMENTITIOUS-BOARD-LINED LABORATORY HOOD

- 1. The superstructure interior shall be fabricated of asbestos-free, acid-resistant, fiber-reinforced cement board at least 1/4-inch thick and manufactured for use in this application. Interior fasteners, brackets, and hinges shall be Type 304 stainless steel.
- 2. Interior access panels shall be flush mounted to minimize eddy currents.
- 3. Fluorescent light panel shall have a vapor-tight stainless steel frame.
- 4. Vertical sliding sash shall have 1/4-inch thick laminated safety glass. Sash frame shall be 18-gauge stainless steel rolled shape, mitered, welded and ground smooth. Sash will run in polished stainless steel guides with nylon bushings and shall employ vinyl-coated over nylon ball-bearing pulleys. Coated steel counterweights shall be concealed in the superstructure.

### B. STAINLESS STEEL-LINED LABORATORY HOOD

- 1. Use 18-gauge Type 304 stainless steel for interior and baffles except worktop, which is to be 16-gauge. Provide No. 4 finish.
- 2. Exposed metal on the interior of the hood shall be stainless steel.
- 3. Vertical sliding sash shall have 1/4-inch thick laminated safety glass. Sash frame shall be 18-gauge stainless steel rolled shape, mitered, welded and ground smooth. Sash will run in polished stainless steel guides with nylon

bushings and shall employ vinyl-coated over nylon ball-bearing pulleys. Coated steel counterweights shall be concealed in the superstructure.

C. RADIOACTIVE ISOTOPE OR CARCINOGEN LABORATORY HOOD

1. Use 18-gauge Type 316 seamless steel for interior and baffles except worktop, which is to be 16-gauge. Polish to No. 4 finish. Provide an integral trough in the worktop and cove corners which have 1/2-inch radius.
2. Exposed metal on the interior of the hood shall be stainless steel.
3. Equip each hood with an absolute filter housing to accommodate prefilter (15 percent ASHRAE) and high efficiency filter (HEPA 99.97 DOP). Provide a gauge to monitor pressure drop across filter.
4. Vertical sliding sash shall have 1/4-inch thick laminated safety glass. Sash frame shall be 18-gauge stainless steel rolled shape, mitered, welded and ground smooth. Sash will run in polished stainless steel guides with nylon bushings and shall employ vinyl-coated over nylon ball-bearing pulleys. Coated steel counterweights shall be concealed in the superstructure.
5. Comply with the Nuclear Regulatory Commission (NRC) standards (Codes 10CFR19 and 190CFR20); and *Ohio Administrative Code (OAC 3701)*.

D. PERCHLORIC ACID LABORATORY HOOD

**Commentary:** *Placement of this type of hood must be reviewed and accepted by OSU Environmental Health and Safety and the University Engineer during the Schematic Design Phase. This is the responsibility of the OSU Project Manager and the A/E.*

1. Use 18-gauge Type 316 seamless steel for interior and baffles except worktop, which is to be 16-gauge. Polish to No. 4 finish. Provide an integral trough in the worktop and cove corners which have 1/2-inch radius.
2. Exposed metal on the interior of the hood shall be stainless steel.
3. Vertical sliding sash shall have 1/4-inch thick laminated safety glass. Sash frame shall be 18-gauge stainless steel rolled shape, mitered, welded and ground smooth. Sash will run in polished stainless steel guides with nylon bushings and shall employ vinyl-coated over nylon ball-bearing pulleys. Coated steel counterweights shall be concealed in the superstructure.
4. Baffles are to be removable.
5. Provide spray-type wash-down system which will wash surfaces behind baffles. Exhaust ductwork and wash-down system for perchloric acid hoods must be in compliance with NFPA 45. The wash-down control and status indication shall be located at the hood. Arrange sash to prevent leakage of wash-down water from the hood.
6. Provide a blow-out panel with two (2) stainless steel arresting devices and stainless steel control cables.
7. Provide for easy visual inspection of hidden surfaces.

## APPENDIX W

---

8. Use no organic coatings, lubricants or sealants.
9. Comply with latest edition of the American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation Manual.
10. A/E shall review the placement of this type of hood with Environmental Health and Safety and the University Engineer during the Schematic Design Phase.

### E. EXPLOSION-PROOF LABORATORY HOOD

1. Same construction as Perchloric hoods noted above except for the following:
2. Provide a blow-out panel in lieu of an automatic air bypass. Blow-out panel must have an arresting device.
3. Any device in the air stream shall be non-sparking and explosion-proof.

---

END OF APPENDIX W



## **THE OHIO STATE UNIVERSITY SUSTAINABILITY PROGRAMS & GUIDELINES**

### **1.1 Introduction**

These Ohio State University (OSU) Sustainability Guidelines were developed to provide tools and resources for OSU staff and outside consultants to reference when addressing the OSU Green Build and Energy Policy 3.10.

### **1.2 Sustainability Programs**

This information provides links to current University policy and procedures

[Sustainability Portal](#)

[President and Provost's Council on Sustainability](#)

[Office of Energy and the Environment](#)

[Energy Services and Sustainability \(ESS\)](#)

[Recycling](#)

[Zero Waste Stadium](#)

[Buckeye Footprint](#)

[Green Building and Energy Policy 3.10](#)

Green Cleaning Program – (future)

[Nonsmoking Policy 7.20](#)

Refrigerant Management Program – (future)

[Recycled Paper Policy 2.01](#)

[Surplus Materials Disposal Policy 4.51](#)

University Energy Costs

### **1.3 LEED Process Guidelines**

This information was developed to provide standard guidelines for use when moving through each step of the LEED process.

LEED [Process Guideline – Short Version](#)

LEED [Process Guideline – Long Version](#)

LEED [Certification Matrix](#)

LEED [Required Signatories](#)

### **1.4 LEED Construction Templates and Checklists**

This information provides standard checklists and templates that can be used during construction.

LEED [Construction Phase Tracking Guideline](#)

LEED [Diverted Furnishings Log](#)

LEED Submittal Log (future)

LEED [Commissioning Requirements](#)

### **1.5 LEED Project Information**

This information provides a link to all current OSU LEED projects and information pertaining to those projects.

OSU LEED Projects (future)

Project Scorecards (future)

Project Boundary Maps (future)

Project Narratives (future)

### **1.6 Additional LEED Information and Training**

This information is provided for additional reference and use.

LEED Training Classes

[USGBC](#)

[LEED Online 2009](#)

### **Basic Security Planning Minimum Design Requirements**

The following minimum design requirements are to be used in the planning and design of all renovations and new construction projects at The Ohio State University. These design intents are based on current risk assessments, however, future changes will need to be accounted for as they present themselves. The design reviewers for The Ohio State University reserve the right to specify additional enhancements or security mandates based on new threat assessments.

#### **Design intents for the minimum perimeter building standards:**

1. All building entrances are to be connected to the centrally supported Alarm and Card Access Management System (ACAMS). All card readers are to be operated by ACAMS. All building entrances require electrically unlocking door hardware or a door contact with a delayed egress exit device per fire code requirements. Exterior door locations shall be equipped with a door position switch. All exit devices shall include fully adjustable latch bolt monitoring and request to exit switches integral to the door hardware. Mortise lock doors shall include latch bolt monitoring and request to exit switches integral to the mortise lock.
2. A minimum of two building entrances are to be equipped with card reader access reporting to ACAMS. One must be near the primary parking area for after-hours access.
3. All roof access and other accessible points of entry (including operable skylights, doors, hatches, etc.) must be equipped with door position switches monitored through the centrally supported ACAMS.
4. Building perimeter security is to include a building control keypad to provide onsite building access control.
5. The project budget will be financially responsible for implementing these standards and will be defined within the Memorandum of Understanding (MOU) of a new facility project.

#### **Design intents for classrooms:**

1. All classrooms will minimally be fitted with brass key core lockset with a thumb-turn latch bolt on the inside ("office function") of the perimeter doors and shatter resistant glazing.
2. Entry doors will need to incorporate shatter resistant glazing into the frame and/or door way. Glazing should not provide a mechanism for easy access of the door handle from the inside.
3. Classroom technology should be secured in one of the following fashions:
  - .1 At a minimum, classroom doors and ceiling spaces need to have conduit runs installed with pull strings to the nearest room containing an ACAMS panel for future expansion.
  - .2 A securable closet must be provided to secure all loose equipment (TV stands, VCR's, DVD players, etc.) in a central location for classrooms sharing equipment.
  - .3 Mounted technology devices will be secured and provided with an ACAMS reporting contact alarm.
  - .4 Technology enhanced rooms will have an ACAMS card reader with alarm keypad and security door contacts on perimeter doors reporting through ACAMS.

#### **Design intents for the "Special Case" security enhancements:**

1. Duress Alarms are required:
  - .1 In close proximity to permanent structures where cash, check, or charge transaction processing areas are located.
  - .2 Any area where external threats are perceived to be likely.

## APPENDIX Y

2. High value asset, whether of significant historical, cultural, artistic or monetary value require appropriate security measures [including but not limited to: ACAMS card reader, keypad, door contact, passive infrared motion sensor (PIR), glass break (GB), duress]. This type of area will include the use of specialized security devices and is to be monitored by ACAMS. Specific case examples include, but are not limited to: the John Glenn collection; college records; the Heisman trophy collection; geological samples; artwork collections; check writing materials; historic memorabilia; and trademark assets.
3. Research, radiation, biological, or chemical use labs must contain the appropriate level of security based on the use and contents of the facility:
  - .1 The minimum of an ACAMS controlled and monitored card reader on entry door reporting through ACAMS.
  - .2 Lab perimeter security and safety devices can include but are not limited to: ACAMS Card Reader, Keypad, Door Contact, PIR, GB, Duress
  - .3 Additional security features are to be required based on specific regulatory requirements.
4. Emergency phones are to be ADA accessible. The amount of emergency phones and their placement is at the discretion of the Facilities Design and Construction Project Manager and a Public Safety representative.

### **Design intents for Closed Circuit Television (CCTV) cameras and Digital Video Recorders (DVR's):**

1. All construction must integrate CCTV and DVR technologies into the building's security plan.
2. All CCTV must be recorded locally and be must able to be monitored by the Department of Public Safety. All CCTV and DVR systems must meet OSU Public Safety requirements for remote viewing.
3. Loading dock areas require recorded CCTV.
4. All after-hours access points must have an interior mounted CCTV camera 15'- 25' from each single or pair of door leaves to monitor inbound traffic.
5. Cash handling operations require CCTV.
6. Parking structures must have cameras positioned to view all pedestrian and vehicular inbound and outbound traffic lanes. Multiple cameras must be positioned to capture license plates as well as driver descriptions.

### **Variance Application:**

The OSU Building Design Standards Security Planning Standards Variance Application is for situations where it would be appropriate to modify/adjust a part(s) of this appendix.



Table with 2 columns: PROJECT (project #, project name) and PROJECT MANAGER (project manager)

Table with 3 columns: VARIANCE REQUESTOR (Name, Company/College/Dept., Address) and (Phone, Email)

This variance application is being submitted to present a situation / conditions where a strict compliance of the Security Planning Standards would result in an unnecessary hardship or cost. Provide below the general reason(s) for the variance, associated costs, benefits, risks, other options that were considered, and any other information that would help explain why this variance is being requested.

Variance requested for: (indicate the specific item for which the variance is requested - ex. Perimeter building standards item 1)

Alternate concept (include all supporting documentation): (describe the concept proposed that will meet the intent of the design standards)

Responsible Fiscal Authority Signature: \_\_\_\_\_ Date

(Please indicate all supporting documentation. Note that follow up documentation may be required to process this variance.)

Committee Reviewers:

Table with 4 columns: Department/Title, Signature (required), Approve, Disapprove^1

Variance request is: Approved \_\_\_\_\_ Denied \_\_\_\_\_

Authorization signature: \_\_\_\_\_ Senior Director, FDC Date

Send the original variance application to the Project Manager for routing

^1 If the variance is disapproved by a reviewer, the reviewer shall attach their reasons for disapproval and any documentation.

**BUILDING INFORMATION MODELING (BIM)**  
**PART 1 GENERAL**

1.0 SCOPE

- A. The Architect/Engineer (A/E), or Contractor shall meet, for projects four million dollars or greater, the BIM Project Delivery Standards (BIM PDS)
  - 1. Project Delivery Standards [http://fod.osu.edu/sites/default/files/ohio-state\\_bim\\_pds.pdf](http://fod.osu.edu/sites/default/files/ohio-state_bim_pds.pdf)
  - 2. Execution Plan [http://fod.osu.edu/sites/default/files/ohio-state\\_bim\\_ep.docx](http://fod.osu.edu/sites/default/files/ohio-state_bim_ep.docx)
  - 3. Video Training - #2 Project Delivery Standards  
<http://www.youtube.com/watch?v=BQJwL8wp2Hw>

END OF APPENDIX Z

## **MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 01 – GENERAL REQUIREMENTS**

2011 Edition, Published July 22, 2011; Division Revision Date: February 7, 2017

### **PART TWO PROVISIONS FOR CONTRACT ADMINISTRATION**

**01 14 00. WORK RESTRICTIONS:** Fully describe all job conditions that will affect phasing and scheduling of the work. Particular attention must be given to scheduling remodeling work in buildings that will remain in operation during remodeling. Examples of some problems encountered are:

- .1 PROVIDING AND MAINTAINING MEANS OF INGRESS AND EGRESS: Temporary entrances and exits must meet code requirements.
- .2 MAINTAINING SECURITY: Areas that are being operated by the Using Agency must be secured from the construction area and vice versa.
- .3 USE OF DOCKING FACILITIES: Sometimes these facilities must be shared between the University and the contractors.
- .4 STORING OF CONSTRUCTION MATERIALS: If adequate areas cannot be provided, delivery schedules will be affected.
- .5 SCHEDULING FOR MOVES BY THE USING AGENCY: If remodeled spaces must be ready for use or vacated by certain dates, name the spaces and give the dates.
- .6 MAINTAINING SERVICES: These requirements should be detailed in the section entitled, TEMPORARY FACILITIES AND CONTROLS.
- .7 DUST CONTROL AND NOISE CONTROL: Temporary partitions required for control of dust and noise should be shown on the drawings. Construction of these partitions may be specified in the section entitled, TEMPORARY FACILITIES AND CONTROLS or in the section in which the partition materials are specified. Refer to paragraph 01 56 16. of these guides.
- .8 All persons on any job site within an operating OSUWMC Health System facility will be required to possess, and have displayed, their OSUWMC ID Badge at all times while working on property.  
All persons on any job site that is NOT within an operating OSUWMC Health System facility will be required to possess, and have displayed, their OSUWMC ID Badge the first day the project is officially tuned over for any level of OSU occupancy.  
Failure to comply with the above listed requirements and failure to properly display a valid OSUWMC ID Badge may result in removal from the worksite.

### **01 31 00. PROJECT MANAGEMENT AND COORDINATION**

#### **01 31 13. INTERRUPTION OF EXISTING SERVICES OR OPERATIONS**

- .1 Whenever it is necessary to interrupt existing services currently in use by the Owner or its tenants, including but not limited to sewer, water, gas, steam, electric, telephone, communication cabling, cable TV, etc., the Contractor shall continue the associated Work on a non-stop 24-hour per day basis until that Work is completed and the service is restored, or at an alternate time required by the Contracting Authority.

## DIVISION 01 GENERAL REQUIREMENTS

- .2 Whenever it is necessary to interrupt existing operations of the Owner or its tenants, including but not limited to docks, elevators, conveying equipment, processes, procedures, etc., the Contractor shall continue the associated Work on a non-stop 24-hour per day basis until that Work is completed and the operations is restored, or at the alternate time required by the Contracting Authority.
- .3 Whenever it is necessary to interrupt existing operations of the Owners automated processing and transporting equipment; such as: automated guided vehicles, pneumatic tube system, pneumatic trash or linen system, etc., the Contractor shall continue the associated Work on a non-stop 24-hour per day basis until that Work is completed and the operations is restored, or at the alternate time required by the Contracting Authority.
- .4 Before Commencement of Work, the Contactor shall apply in writing to, and receive approval in writing from, the Owner, through the A/E or Owner designee, to establish a time when interruption of the service or operations will cause a minimum of interference with the activities of the owner and its tenants.

END OF DIVISION 01 – GENERAL REQUIREMENTS



**MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 08 - OPENINGS**

2007 Edition, Published April, 2007

Revised February 7, 2017

*The Special Requirements indicated in this appendix shall be incorporated in all Design Documents for Medical Center Projects. These Special Requirements consist of exceptions, revisions or additions to the base Building Design Standards.*

**08 70 00. HARDWARE**

08 70 20. PROHIBITED MATERIALS AND INSTALLATIONS:

.6 ALL SURFACE MOUNTED AND CONCEALED VERTICAL ROD EXIT DEVICES unless approval is received from the Medical Centers' Facilities Services Office.

.9 ROLLER LATCHES are prohibited.

08 71 20. LOCKS:

.1 FUNCTIONS:

Door Location or Usage	BHMA No.	Function
.1.8 Patient Room Door pull latches	***	Hollow Metal Door with Glynn Johnson push
.1.8 Patient Bathroom	***	Mortise passage set

.1.10 Acceptable lever lock sets are:  
No Substitutions / No equals

<u>Manufacturer</u>	<u>Series</u>	<u>Lever Style</u>
A. Sargent	8200	
B. Stanley Best	35H	15J or 3J
<u>Best 35H Series is available only to Ohio State University. No substitutions / No equals. These come in pushbutton, classroom, storeroom, and passage set functionality.</u>		
C. Corbin Russwin	ML2000	
<u>These come in pushbutton, classroom, storeroom, and passage set functionality.</u>		

All shall be mortise type. All finishes shall be 626 or equivalent.

**Commentary:** *All 3 locks can also be ordered as bathroom locks. All 3 can be ordered with deadbolts.*

08 71 90. KEYING:

Approved keys are: Stanley Best Coremax keys. No Substitutions / No equals:

- A. 1AM1ML11KS716KS800 – ML1 Keyway
- B. 1AM1MJ11KS716KS800 – MJ1 Keyway
- C. 1AM1MM11KS716KS800 – MM1 Keyway
- D. 1AM1MK11KS716KS800 – MK1 Keyway
- E. Pre-cut on the coremark of Access Control's choosing.

Approved cores are: Stanley Best Coremax cores. No Substitutions / No equals:

- A. 1CM7MM11626 – MM1 Core
- B. 1CM7ML11626 – ML1 Core

- C. 1CM7MK11626 – MK1 Core
- D. 1CM7MJ11626 – MJ1 Core
- E. Prepinned by Stanley on the coremark of Access Control's choosing.

All finishes shall be 626 finish or equivalent.

Approved Keybox(s) are: Global Facilities Management System (GFMS). No substitutions / No equals:

- A. Size and need to be determined by OSUWMC security management team.
- B. Associated interior panel must be specified to accept the 7-pin SFIC's.
- C. Shall have a magnetic card reader installed on exterior of box.

#### 08 75 00 BATTERY POWERED STAND-ALONE LOCKS

##### 1. Offline / Standalone Wi-Fi Sargent Locks

- A. Sargent Passport 1000 P2 Mortise lock that includes:  
No substitutions / No equals
  - a. Magnetic stripe reader
  - b. HID multiclass SE
  - c. No Keypad (unless otherwise noted)
- B. Power shall be provided by battery.
- C. DHCP support shall be provided.

##### 2. Accessories

- A. Door contacts
  - a. Central Magnetic Contacts 1078/1076 Series
- B. Request to Exit motion detectors
  - a. Bosch DS160
- C. Electric strike
  - a. Von Duprin 6210
- D. Delayed Egress "Rocking" Electromagnetic Locks  
All delayed egress "Rocking" electromagnetic lock mounting fasteners shall be installed with locktite applied by the installer.
  - a. Schlage 490DEP
- E. Electromagnetic Lock  
All electromagnetic lock mounting fasteners shall be installed with locktite applied by the installer.
  - a. Schlage Magforce 490+ Series
- F. Panic buttons
  - a. Honeywell 269R surface mounted with recessed switch.
- G. Emergency release for automatic doors
  - a. Securiton EEB2 30 second delay exit button.

---

END OF DIVISION 08 - OPENINGS

## **MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 14 – CONVEYING SYSTEMS**

2007 Edition, Published April 2007

*The Special Requirements indicated in this appendix shall be incorporated in all Design Documents for Medical Center Projects. These Special Requirements consist of exceptions, revisions or additions to the base Building Design Standards.*

### **14 00 00. CONVEYING SYSTEMS**

#### **14 20 00. ELEVATORS**

.2 USE OF EXISTING ELEVATORS: Elevators deemed acceptable to use will be inspected by OSUMC Facilities Operations personnel before and after construction to appraise any damage caused by this use. Pending approval by OSUMC Facilities Operations, the Associate shall designate the appropriate elevator for use.

#### **14 20 01. GENERAL REQUIREMENTS:**

.2.1.1 The contractor shall respond to entrapments calls within thirty (30) minutes after notification, including evenings, weekends and holidays. The contractor shall respond to maintenance callbacks within forty-five (45) minutes after notification, including evenings, weekends and holidays.

14 20 02. REQUIREMENTS: Elevator Design and Installation shall comply with the current Ohio Elevator Code, Escalators Code and all referenced national codes.

.6 Hydraulic elevator machine rooms should not be located next to patient care rooms, conference rooms or offices without sound deadening material.

.11 Provide signs for firefighters' operation at designated fire floor, etched with the hall call station. Provide occupants signage at each floor with an etched graphic with the hall call station that says "Do Not Use Elevator In Case of Fire" per elevator code.

.15 Design at least one elevator in each building to serve the mechanical equipment floor(s) of the building. The elevator shall be large enough to handle major pieces of equipment of the equipment room.

#### **14 20 03. GENERAL DESIGN AND PLANNING:**

.4.1 The hydraulic mechanical room should not share a common wall with patient care rooms, conference rooms or offices. The entrance should not be accessed through a patient care room/area, conference room or office.

.5.4 An elevator consultant shall provide a recommendation on the number of elevators in each bank necessary to be on emergency power. The number of elevators in each bank that shall be on emergency power shall be a minimum of one.

.5.14.4 Connect to the OSUMC telephone system for a fully functional system. Follow OSUMC IS guidelines to make the final termination.

.5.15.6.1 The in car operating panel shall be etched with the building name and elevator number, the fire fighter operation instructions, elevator capacity.

.5.16 Consideration shall be given to the type and frequency of traffic on each elevator for heavy-duty car sills.

**14 92 00. PNEUMATIC TUBE SYSTEMS**

14 92 00. PNEUMATIC TUBE SYSTEMS

- .1 SYSTEM ARCHITECTURE: The existing system consists of a 4" Swisslog CASIII System extended throughout the Doan, Rhodes and James Cancer complex. In addition, there is a separate Swisslog CTS 6" TL 2005 System that extends throughout Ross Heart Hospital with branches to the Rhodes/Doan Hall labs and Emergency Department. Both front ends for the existing systems reside in Doan 009.
- .2 CASIII SYSTEM: Any addition or modification to the existing 4" system shall utilize latest release of electronics and communicate with the existing CASIII front end. A majority of the devices on the 4" system utilize emergency power. In order to strive for full functionality in an emergency situation, it is recommended that any new devices requiring an electric service utilize emergency power.
- .3 CTS 6" TL 2005 SYSTEM: All devices on this system are fed from emergency power enabling operation in emergency situations. In order to maintain consistency, any additions to the existing system shall utilize emergency power if an electrical service is required. Any extension of the existing 6" system shall be the Swisslog CTS 6" TL 2005 System. Any new system shall be Swisslog and communicate with the existing front end.

---

END OF DIVISION 14 – CONVEYING SYSTEMS

## **FS-6. A REVIEW OF ENERGY CONSERVATION REQUIREMENTS (Cont'd)**

### **MEDICAL CENTER EXCEPTIONS TO DIVISION FS – FACILITIES SERVICES**

#### **PART FOUR DOCUMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRICAL CONSTRUCTION**

#### **FACILITY SERVICES - REQUIREMENTS FOR PLUMBING, FIRE PROTECTION, HVAC, AND ELECTRIC DOCUMENTS**

---

2007 Edition, Published April, 2007

#### **FS-1. SEPARATE DOCUMENTS REQUIRED**

- .2 SEPARATION OF PLUMBING; AND HEATING, VENTILATING AND AIR CONDITIONING: The University requires that the complete separation of documents for these Divisions of The Work be made evident by prohibiting use of the word "MECHANICAL" when writing specifications for these Divisions and when making references to the contracts and contractors for any of these parts of The Work. In preparation of specifications, numbering of sections for Plumbing shall be preceded by "22"; and Heating, Ventilating and Air Conditioning by "23". Any system of numbering (either an alphanumeric system or a decimal system) may be used for the sections, articles, and paragraphs comprising these Divisions, at the Associate's option.

On drawings avoid using "mechanical" to describe pipe or duct chases, HVAC or electric equipment rooms, etc.

#### **FS-2. DESIGN CONSIDERATIONS**

- .1 DIRECT DIGITAL CONTROL (DDC) SYSTEM: To achieve precise control of all HVAC systems and to provide the means to integrate standard control functions with energy saving strategies, it is intended that all newly constructed and remodeled buildings on the Columbus campus be controlled using stand alone microprocessor based Direct Digital Control (DDC) computer systems. All hardware, software, and miscellaneous equipment required to insure that the DDC system can be managed from within the building and from a remote control center shall be provided as a part of the project. Control Centers now in existence or planned for the future are:

OSU Medical Center:

University Hospitals, James Cancer Hospital, University Hospital East, Medical Center Outreach Facilities

Each Associate shall submit schemes for connecting new DDC equipment. All DDC systems shall be connected to the control center(s) using the Medical Center's fiber optic network, a hard-wired communication trunk, or a telephone communications trunk, as dictated by the capabilities of the system selected and by the location of the building being controlled.

All newly constructed and remodeled buildings/projects are to be controlled using BACnet compliant Direct Digital Controls. All controls shall tie in to the existing Delta Controls building automation front end. See MC Appendix A for requirements.

- .1.1 OSUMC will require one BACnet Broadcast Management Device for every floor of every building. The OSUMC network will be segmented so that each floor will be a separate subnet from all others.
- .1.2 Provisions for BACnet compliant DDC Systems for OSUMC are described thoroughly in MC Appendix A.

**FS-6. A REVIEW OF ENERGY CONSERVATION REQUIREMENTS (Cont'd)**

- .1.3 OSUMC Building Automation Systems shall be based on Delta Controls. OSUMC Facilities shall be consulted for other manufacturers to be specified.
- .4 **METERING:** Separate and permanent meters for all utilities (gas, electric, water, chilled water, and steam) shall be provided for each building. Some buildings and systems will require additional sub-metering to facilitate adjustment of charges for water supply and sewage discharged. Also see Sewer Auxiliary Metering Systems in Appendix. See Index for other references.
  - 4.4 Sub metering requirements shall be coordinated with OSUMC Facilities Operations.

**FS-3. COORDINATION OF CONTRACT DOCUMENTS**

- .5 **USE OF PREMISES:** Make reference to the applicable portions of Division 1. If routing of trucks hauling materials to and from the site cannot be adequately described in the specifications, show routes on the Location Plan.
  - 5.3 Construction barriers and OSUMC construction requirements (i.e. interim life safety measures, special pressurization requirements, etc) shall be shown on plans also.
- .17 **PAINTING:** Cleaning and painting of Plumbing, HVAC, Fire Protection, and Electrical items and equipment exposed to view should be specified in Division 9. If concealed installations require painting before being concealed, list the installations and specify that materials and application be as specified in Division 9. Do not specify painting of the same surface under more than one Division except shop prime coats, where protection is needed, color banding and flow arrows. See 09 91 23.1.

**USE OF INK MARKING PENS ON ANY SURFACE IS PROHIBITED.** Marks bleed through paint or other finishes.

- .17.1 **COLOR CODING OF PIPING:** Specify that, after piping has been finish painted, the installer of the piping identify the type of service lines with applied color bands and stenciled letters and indicate direction of flow with stenciled arrows. Color bands shall be 1-inch wide, finished in gloss enamel; lettering and arrows shall be same color as the bands. Specify that indicators be applied at connections to pumps, chillers, and other equipment; at entrances to spaces; adjacent to valves; near access doors to pipe spaces; and at 20-foot maximum intervals on long pipe runs. Additionally, indicators shall be on both sides of partitions penetrated by piping, at least once in every space. Specify that letters be positioned to be easily read from a normal standing position.

**FS-6. A REVIEW OF ENERGY CONSERVATION REQUIREMENTS (Cont'd)**

.17.1.1 Use the following band colors and letter designations:

<b>Type of Service</b>	<b>Color</b>	<b>Designation</b>
<b>PLUMBING PIPING (Show direction of flow and include pressure rating where applicable)</b>		
Compressed Air	White	CA
Drain	Room Color	
Natural Gas	Yellow	Gas
Hydrogen	Red	HYD
Nitrogen	Black	NIT
Oxygen	Green	OXY
Vacuum	Room Color	VAC
Domestic Cold Water	Light Blue	DCWS
Domestic Hot Water	Dark Blue	DHWS
Domestic Hot Water Return	Dark Blue	DHWR
Deionized Water	Room Color	DZDW
Distilled Water	Room Color	DSTLW
Soft Water	Medium Blue	SFTW
Oil, Fuel, or Hydraulic	Orange	Oil
Medical Air	Yellow /Black	Med Air
Medical Vacuum	White/Black	Med Vac
Nitrous Oxide	Blue/White	Nitrous Oxide
Carbon Dioxide	Gray/Black	Carbon Dioxide
Instrument Air		Instrument Air
Laboratory Air		Lab Air
Laboratory Vacuum		Lab Vac
Reverse Osmosis Water		RO

**HEATING AND COOLING PIPING (Show direction of flow and pressure rating)**

High Pressure Steam 125PSI	Aluminum/Orange Band	HPS
Med. Pressure Steam 50PSI	Aluminum	MPS
Low Pressure Steam 15PSI	Aluminum	LPS
Boiler Feed Water	Green	BLR F
Chilled Water Supply	Black	CWS
Chilled Water Return	Black	CWR
Condensate Water	Aluminum	COND
Condenser Water	Purple	CDSR
Hot Water Heating Supply	Lime Green	HWHS
Hot Water Heating Return	Lime Green	HWHR
Pumped Condensate Water	Black	PCD

**FIRE PROTECTION PIPING**

Fire Line	Red	FL
-----------	-----	----

**FS-6. A REVIEW OF ENERGY CONSERVATION REQUIREMENTS (Cont'd)**

**FS-4. SUBMITTALS**

- .4 WARRANTIES, OPERATION AND MAINTENANCE MANUALS: At the time of Beneficial Occupancy of the project, four approved copies of warranties, instruction sheets, catalogue data, and final shop drawings secured in binders shall be forwarded to the University Architect's Office. Also see 01 78 23. Provide full information (trim sheets and log sheets) defining all conditions, quantities of refrigerant, pressures, temperatures, number of belts, belt sizes, etc. during the testing operations of each piece of equipment.

**FS-5. SAFETY REQUIREMENTS**

- .2 Contractor shall be required to comply with all requirements for Material Safety Data Sheets (MSDS's), lockout and tagout procedures, confined space entry requirements, hot work permits, construction site fire protection, fall protection for all contractor and subcontractor employees, hazardous materials abatement procedures, prohibition of mercury-containing materials, etc. Contractors working within Medical Center facilities shall be required to comply with the Medical Centers' interim life safety measures.

**FS-6. A REVIEW OF ENERGY CONSERVATION REQUIREMENTS**

The subject of energy conservation is discussed in various sections of these BUILDING DESIGN STANDARDS. This review is made for the purpose of consolidating all requirements for this important part of design under one heading for easy reference.

**.1 GENERAL REQUIREMENTS**

- .1.2 In the design of the HVAC and Electrical systems, consideration must be given to building utilization by planning for conservation of energy during summer and winter vacations and for other periods of minimum occupancy. Research laboratories, spaces for animals, and other spaces which might require 24 hours/day operation must be serviced by systems separate from office systems which may require only 8 hours/day operation, and classrooms which may be shut down during summer and vacation periods. In general, all space within the Medical Center operates 24 hours/day, 365 days/year.



## **FS-6. A REVIEW OF ENERGY CONSERVATION REQUIREMENTS (Cont'd)**

### **.3 SYSTEM DESIGN REQUIREMENTS**

.3.2 Design temperatures for heating and air conditioning systems shall be as follows:

Summer: (Space conditioning)

Outside conditions, 92 degrees FDB and 74 degrees FWB

Inside conditions shall conform to the latest edition of the AIA Guidelines for Design and Construction of Health Care Facilities and as coordinated with OSUMC Facilities Operations. For those spaces not listed in these Guidelines, the inside conditions shall be 70-72 degrees FDB, 30-50% RH.

Winter: (Space Conditioning)

Outside conditions, +1 degrees FDB

Inside conditions shall conform to the latest edition of the AIA Guidelines for Design and Construction of Health Care Facilities and as coordinated with OSUMC Facilities Operations. For those spaces not listed in these Guidelines, the inside conditions shall be 70-72 degrees FDB, 30-50% RH.

Winter for preheat coil sizing on 100% outdoor air fan systems:

Outside conditions, (minus) -22 degrees FDB

Coil Leaving Air conditions, +55 degrees FDB

MC Relative humidity should conform to the latest edition of the AIA Guidelines for Design and Construction of Health Care Facilities.

## **FS-7. EQUIPMENT**

### **.2 RELOCATING EXISTING EQUIPMENT**

.2.1 Relocation of existing equipment must include disconnecting and moving to new location as well as restoration and capping utilities at the old location. Utilities, and utility support systems not intended for future use will be removed back to the source.

---

END OF FACILITY SERVICES

## **MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 21 – FIRE SUPPRESSION**

2007 Edition, Published April 2007

*The Special Requirements indicated in this appendix shall be incorporated in all Design Documents for Medical Center Projects. These Special Requirements consist of exceptions, revisions or additions to the base Building Design Standards.*

### **21 00 00. FIRE SUPPRESSION**

#### **21 00 03. GENERAL PROVISIONS**

.3.1 Existing fire pumps shall be flow and pressure tested by the fire protection contractor to confirm actual availability of water.

.5 Areas under renovation not currently having sprinklers shall be added as part of the project. Floor piping shall be sized such that provisions for future extension of sprinklers to all non-sprinkled areas of the floor and/or zone can be made. Areas of renovation having any sprinkler head type but semi-recessed shall be replaced as part of the renovation by a semi-recessed sprinkler head.

#### **21 00 09. RELATED WORK IN GENERAL CONSTRUCTION**

.2 Fire Hose Cabinets are not required.

### **21 10 00. WATER-BASED FIRE SUPPRESSION SYSTEMS**

#### **21 12 20. FIRE HOSE CABINETS AND ACCESSORIES:**

21 12 20 FIRE HOSE CABINETS are not required by OSUMC.

.7 RENOVATION PROJECTS: Require that the OSU Medical Center Facilities Operations be advised to take possession, before construction begins, of existing fire extinguishers for safe keeping.

### **21 13 00. FIRE-SUPPRESSION SPRINKLER SYSTEMS**

.4 DRY SPRINKLER SYSTEMS: Provide a low pressure switch on all system to detect a gradual loss of air pressure. Connect switch to fire alarm system as a distinct zone. Dry sprinkler systems shall be specified for areas susceptible to freezing temperatures, including but not limited to; dock areas, garage connectors, overhead building connectors, building overhangs/canopies, etc.

.4.1 Air compressor shall be on a dedicated electrical emergency circuit.

.5 No zone shall be dependent upon another zone. Each zone shall be capable of being drained and filled without draining another zone or the remainder of the sprinkler riser to facilitate repairs, etc.

.8 Sprinkler heads shall be semi-recessed, polished chrome with matching escutcheon in finished ceiling area. Concealed heads are not permitted, unless otherwise approved by OSU Medical Center Facilities Operations. Areas of renovation not having semi-recessed heads shall have the heads replaced to semi-recessed as part of the project.

**21 13 00. FIRE-SUPPRESSION SPRINKLER SYSTEMS (Cont'd)**

- .9 Fire suppression piping shall be Schedule 40 piping at a minimum. Schedule 10 is not permitted.
- .10 Operating rooms shall be suppressed with a pre-action fire suppression system.

---

END OF DIVISION 21 – FIRE SUPPRESSION

## **MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 22 – PLUMBING**

---

2007 Edition, Published April 2007

*The Special Requirements indicated in this appendix shall be incorporated in all Design Documents for Medical Center Projects. These Special Requirements consist of exceptions, revisions or additions to the base Building Design Standards.*

### **22 00 00. PLUMBING**

#### **22 00 03. GENERAL PROVISIONS**

.3 CODES: All materials and installation shall also be compliant with the current AIA Guidelines for Design and Construction of Health Care Facilities.

#### **22 00 07. TESTING**

.8 Medical gas systems: Test as recommended by current editions of National Cylinder Gas Codes and NFPA 55, 99C. Systems shall be certified by a third party certifier with ASSE 6001 certification. Certifier shall be hired by the Associate.

### **22 05 05. PLUMBING MATERIALS AND METHODS**

#### **22 05 20. METERS, GAUGES AND THERMOMETERS**

.2.1 Gauges shall have ball valve shut-off.

.3.2 Additionally, thermometers are required at the inlet and outlet of all pressure reducing stations, domestic hot water pumps and master mixing valves.

#### **22 05 25. VALVES**

.1.2 Valve tags shall be tagged with OSU Medical Center nomenclature as: service-building ID (2 letter designation)-floor-valve number. For example, a domestic cold water valve on the 2<sup>nd</sup> floor of Rhodes would be tagged DCW-RH-2-34.

.1.3 Concealed valve locations shall be indicated by color coded tags adhered to the ceiling T-bars. Colors shall match pipe labeling color specification.

.1.4 Design requirements:

.1.4.1 Shut-off valves shall be provided on all branches off main water lines and ahead of dielectric unions. Branches shall be provided with drain valves to facilitate drainage of branches. Shut-off valves shall be located as necessary to allow maintenance/repair of system components with no disruption to building services. Required locations for shut-off valves include, but not limited to, the inlet and outlet of all pieces of equipment, at each floor branch from the riser, at each branch off the main floor distribution piping.

.1.4.3 Unions and Fittings: A union or bolted flange fitting shall be provided downstream of, and within approximately 12 in. or at least 3 pipe diameters, and adjacent to both inlet and outlet of pumps and other equipment. Unions should be independent devices. Combination valves/unions are not acceptable.

- .1.4.4 Flush Valves: Expose for easier maintenance except in high security areas where enclosure would be required (prisoner holding or psychiatric population as examples).
- .2 GATE VALVES: prohibited for 2-1/2 inches and smaller.
- .5 GLOBE AND ANGLE VALVES: prohibited.
- .8 BUTTERFLY VALVES: 2 inch and larger, ductile iron body, bronze disc, extended neck, geometric drive, molded-in seat liner, stainless steel stem, EPDM rubber liner, 125 pounds. Lug or wafer style.
- .10 BALANCE VALVES: Install balance valves in domestic hot water return systems as necessary. Provide separate shut-off valves and balance valves.
- 22 05 50. VIBRATION AND SEISMIC CONTROLS
- .3 Provide vibration isolators and inertia pads under air compressors.
- 22 07 00. PLUMBING INSULATION**
- 22 07 16. PLUMBING EQUIPMENT INSULATION
- .1.1 Domestic hot water storage tanks are prohibited.
- .1.2 Domestic cold water tanks are prohibited, unless approved by OSUMC Facilities.
- 22 10 00. PLUMBING PIPING AND PUMPS**
- 22 10 05. PIPE AND PIPE FITTINGS
- .4.2 5 inch and larger, hard drawn type L copper pipe with cast bronze or wrought copper class 150 lb. brazed fittings.
- .6.1 Appropriate for reverse osmosis water systems and deionized water systems also.
- .6.2 Compressed air piping: galvanized steel piping is prohibited.
- .6.3 This section shall not applicable for medical oxygen.
- .8 Type M copper tubing is prohibited.
- .10 PUMPS
- .10.1 Deionized water pumps
- .10.2 Domestic water pumps: iron housing with brass impeller. Domestic water pumps shall be on emergency power.
- 22 14 00. FACILITY STORM DRAINAGE**
- .1.2 Roof overflow drains shall not empty onto public access areas.

## **22 20 00. PLUMBING SYSTEMS**

### **22 20 06. DOMESTIC HOT WATER**

- .1 Design Concept: Domestic hot water systems utilize steam reduced down from 70#, 400 degF steam stations. The domestic hot water is to be generated at 140 degF, with the capability of providing thermal shock up to 160degF. Domestic hot water is circulated throughout the complex to deliver 125-135 degF at the outlets. Monitoring of the domestic hot water supply and domestic hot water return shall be through the building automation system at the domestic hot water heaters and on the branch risers of each floor served. Consult with OSUMC Facilities for other special monitoring requirements. Provide a master mixing valve with isolation valves and bypass for maintenance in lieu of individual mixing valves at each faucet. The domestic hot water system shall be on emergency power.
- .1.1 The domestic hot water system shall be designed with recirculating lines and pumps, regardless of system size. Branches greater than 20 feet from the main shall include a domestic hot water return line.
- .1.5 Storage tanks are prohibited. Steam fired semi-instantaneous water heaters shall be provided. Water heaters shall be designed with 100% redundancy such that if the largest water heater fails the building will continue to be fully served with domestic hot water.

### **22 20 07. SOIL AND WASTE SYSTEMS**

- .2.14 Sewage ejector pumps: Where required, shall have a minimum of two (2) equally sized pumps so that a pump is available in the event of one pump failure. Pumps shall be automatically alternated on a monthly basis. Pumps shall have dual mechanical seals with a seal failure alarming to the BAS. The pump shall be designed to operate for a minimum of three minutes per cycle to prevent short cycling and premature pump failure. Sump capacity shall be designed to not exceed 12 hours of discharge load. Pumps shall be on emergency power in the event of normal power failure to prevent sewage backup.

## **22 40 00. PLUMBING FIXTURES**

- .3.1 Bariatric water closets, where needed, shall be floor mounted, back outlet.
- .3.4 Shower mixing valves shall be of the pressure balancing type.
- .3.8 All sinks shall have aerators removed.

### **22 60 00 MEDICAL GAS SYSTEMS**

- .1 INSTALLATIONS: All medical gas piping systems shall be installed by ASSE 6010 certified installers. Documentation of certification shall be provided prior to installation and maintained on the jobsite. The installation shall be certified by a third party hired by the Associate. All installations shall conform to the latest edition of NFPA 99.
- .2 MASTER ALARM PANELS are currently located in Doan 009 and in Rhodes S126. Any new master alarms shall be tied into these existing systems. If existing master alarm points are no longer available in these panels, provide a new master alarm panel

adjacent to these existing panels. Coordinate number of points for new panel with OSUMC Facilities Operations.

- .3 ZONE VALVE BOXES: Existing zone valve boxes shall be replaced when renovating an area served by an existing zone valve box that does not meet the requirements of the current code. Coordinate with OSUMC Facilities Operations. Zone valve boxes shall be labeled by the contractor with the rooms served, per NFPA 99. Zone valve boxes shall also be labeled with a unique identifier, corresponding to OSUMC nomenclature – VB-building-floor-number – such as VB-RHH-4-3 for a zone valve box in the Ross Heart Hospital on the 4<sup>th</sup> floor. Consideration shall be given for zone valve boxes with provisions for area alarm sensor connections.
- .4 MEDICAL GAS INLETS/OUTLETS: Shall be Chemetron adapter compatible. Coordinate replacement of existing medical gas inlets/outlets with OSUMC Facilities Operations.
- .5 LABELING: Ensure that all labeling required by the current NFPA 99 is specified and installed as part of the project.

#### 22 61 00 MEDICAL AIR SYSTEMS:

- .1 Piping: Medical air piping shall be brazed, ASTM B819 specification hard drawn Type L copper seamless medical gas tubing. Compression fittings, flared fittings and memory-metal couplings are prohibited.
- .2 Equipment: Medical air compressors shall be triplex units designed such that the full load of the building can be carried with the largest compressor out of service. Medical air compressors shall be single stage reciprocating type, oil free compressors, Liquid ring compressors are prohibited. Automatic alteration of compressors shall be provided to allow division of operating time. All medical air compressors shall be on emergency power. Air dryers shall be desiccant type.

#### 22 62 00 MEDICAL VACUUM SYSTEMS:

- .1 Piping: Medical vacuum piping shall be brazed, ASTM B819 specification hard drawn seamless medical gas tubing. Compression fittings, flared fittings and memory-metal couplings are prohibited. Main and branch piping shall not be less than  $\frac{3}{4}$ " in size. Any existing medical-surgical vacuum less than  $\frac{3}{4}$ " in the area of renovation shall be increased in size to meet this requirement.
- .2 Equipment: Medical vacuum pumps shall be triplex units designed such that the full load of the building can be carried with the largest pump out of service. Medical vacuum pumps shall be oil flooded rotary screw type. Liquid ring vacuum pumps are prohibited. Automatic alteration of pumps shall be provided to allow division of operating time. All medical vacuum pumps shall be on emergency power.
- .3 Waste anesthetic gas disposal (WAGD) shall be piped individually out of each room, where required, and then ties into the medical vacuum piping. A dedicated WAGD producer shall not be provided.

#### 22 63 00 MEDICAL GAS SYSTEMS:

- .1 Existing manifolds in Rhodes and Doan Hall exist for nitrous oxide, nitrogen and carbon dioxide that serve Rhodes, Doan, James and Ross Heart. Any tie-in to these existing manifolds shall include analysis into the size of the manifold, number of cylinders, frequency of change out, current code compliance, etc to ensure that the manifold can support the additional load being added.

- .2 Piping: Medical gas piping shall be brazed, ASTM B819 specification hard drawn Type L copper seamless medical gas tubing. Compression fittings, flared fittings and memory-metal couplings are prohibited.

---

END OF DIVISION 22 - PLUMBING



## **MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

2007 Edition, Published April 2007

; Division Revision Date: June 30, 2016

*The Special Requirements indicated in this appendix shall be incorporated in all Design Documents for Medical Center Projects. These Special Requirements consist of exceptions, revisions or additions to the base Building Design Standards.*

### **23 00 00. HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

#### **23 00 03. GENERAL PROVISIONS**

- .4.1 Provide ceramic bearings on fans controlled by a VFD for protection against eddy current bearing failures. Bearing life per Anti-Friction Bearing Manufacturers Association rating procedures shall be 90 percent expectancy of reaching at least 150,000 hours under design conditions.
- .4.3 OSUMC Facilities Operations shall be provided with the above mentioned report, with the following information:
  - .4.3.3 Dates of maintenance at start-up, periodic inspections and scope of maintenance services performed.
- .6 Systems serving patient care areas and systems serving clinical buildings as a whole shall be designed with N+1 redundancy such that the areas and building can still fully function with the largest piece of equipment out of service.
- .7 The use of duct liner is strictly prohibited.

#### **23 00 07. TESTING**

- .1.1.3 Water Chiller and Boiler Check Out: Specify that a factory-trained serviceman employed by the manufacturer perform adjustments, start-up, tests, and provide syllabus-of-training plus instructions to designated University operating personnel. Training by the manufacturer shall be coordinated with the Medical Center Facilities Services.
- .2 The balancing contractor shall be hired by the A/E.

#### **23 05 05. HVAC SPECIALTIES**

##### **23 05 20. METERS, GAUGES AND THERMOMETERS**

- .1.8 Utility metering shall support connection to the OSUMC Building Automation Delta Controls front-end through a BACNet compliant system to monitor for the purpose of improving operational efficiency of the building systems.
- .2.1 Gauges shall be installed with ball valve shut-off. Gauges should also be installed upstream and downstream of pressure reducing stations. Gauge range shall be applicable to the installation.
- .3.1 Thermometer scale range should be applicable to the installation.

## **MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

2007 Edition, Published April 2007

; Division Revision Date: June 30, 2016

- .3.2 Required applications include hot water converters, domestic water heaters, water tempering stations, air handling unit heating coils, air handler cooling coils, pressure reducing stations, chiller and condenser water systems.

### **23 05 25. VALVES**

- .9.1 Shut-off valves with ball drain valves shall be provided in branches and risers.
- .10 Valve tags shall be tagged with OSU Medical Center nomenclature as: service-building ID (2 letter designation)-floor-valve number. For example, a heating hot water supply valve on the 2<sup>nd</sup> floor of Rhodes would be tagged HWHS-RH-2-34.

### **23 07 00. HVAC INSULATION**

#### **23 07 16. EQUIPMENT INSULATION**

- .3 Chilled water pumps should be insulated with removable, reusable blanket insulation

#### **23 07 19. PIPING INSULATION:**

- .2.9 Provide removable, reusable blanket insulation for applications needing routine maintenance, including but not limited to, steam pressure reducing stations, strainers, pumps, chillers, etc.

### **23 09 00. INSTRUMENTATION AND CONTROL FOR HVAC:**

- .1 All newly constructed and remodeled buildings/projects are to be controlled using BACnet compliant Direct Digital Controls. All controls shall tie in to the existing Delta Controls building automation front end. See OSUMC design standard for Building Automation Systems (MC Revised Appendix A).
  - .1.1a OSUMC will require one BACnet Broadcast Management Device for every floor of every building. The OSUMC network will be segmented so that each floor will be a separate subnet from all others.

#### **23 09 05. HVAC BUILDING SYSTEMS CONTROL:**

- .1 See OSUMC design standard for Building Automation Systems in Medical Center Special Requirements Appendix A.

### **23 20 00. HVAC PIPING AND PUMPS**

#### **23 20 03. PIPING**

- .1.2 Valve tags shall be tagged with OSU Medical Center nomenclature as: service-building ID (2 letter designation)-floor-valve number. For example, a heating hot water supply valve on the 2<sup>nd</sup> floor of Rhodes would be tagged HWHS-RH-2-34.
- .1.3 Valve number directory shall be noted on the as-builts.

**MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

2007 Edition, Published April 2007

; Division Revision Date: June 30, 2016

23 20 05. PIPING MATERIALS:

- .4.3 Press fittings for copper pipe HHW systems larger than 2-inch diameter require prior approval by OSUMC Facilities.
- .5.2 Grooved Piping Systems for chilled water require prior approval by OSUMC Facilities.
- .6.1 Grooved Piping Systems for condenser water require prior approval by OSUMC Facilities.
- .6.2 PVC piping shall not be used.

23 20 13. PUMPS:

- .3 Steam powered condensate return systems shall be supplied with sight glass.
  - .3.2 Combination pump-trap assemblies shall be utilized on systems with modulating steam valves to prevent condensate backup.

**23 30 00. HVAC AIR DISTRIBUTION**

23 30 05. AIR HANDLING UNITS WITH AND WITHOUT COILS:

- .2 MULTIPLE FAN UNITS: Multiple fan units shall be provided for patient care areas, including but not limited to patient room units, operating room units, radiology area units, emergency department units, procedural area units.
- .5 INTERIOR SURFACES: All interior panels shall be solid metal covering insulation. No perforated panels are allowed.
- .7.2 Wheels shall be of heavy gauge welded design.
- .7.4 Air handling units serving patient care areas shall be on emergency power.

23 33 00. AIR DUCT ACCESSORIES

- .1.1 INSTALLATION: Specify that, after dampers are installed, the contractor shall operate each damper through all positions during air handling unit operation to assure free damper operation under an OSUMC representative.
- .1.2 All fire and smoke dampers shall be provided with access panels for routine inspection and maintenance.
- .1.4 LABELING: All fire and smoke dampers shall be labeled in accordance with OSUMC requirements. Dampers shall be labeled with either FD for fire damper, SD for smoke damper or FSD for combination fire/smoke damper, building abbreviation, floor and number. For example, a smoke damper on the 5<sup>th</sup> floor of Rhodes Hall shall be labeled SD-RH-5-19. Any modifications, deletions or additions within existing buildings shall have the number coordination performed with OSUMC Operations. A color coded dot shall be placed on the ceiling tile grid at the location of the access panel for ease of maintenance.

## MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

2007 Edition, Published April 2007

; Division Revision Date: June 30, 2016

- .1.5 Provide means of notifying the building automation system when a smoke damper or fire smoke damper has closed.
- .1.6 Smoke dampers shall be electrically operated.

### 23 34 00. HVAC FANS

- .1 GENERAL REQUIREMENTS: Centrifugal fans are preferred for supply and return air requirements. Air handling units shall be designed as draw-through units. Tubular centrifugal, axial and propeller fans may not be used unless written authorization is obtained from OSUMC Facilities.

### 23 36 05. AIR TEMPERING SYSTEMS:

- .1.1 Outside air shall be controlled via two separate dampers. – a two-position minimum outside air damper and a modulating economizer damper – on all systems.
- .2.1 General: Equipment shall be of adequate size to handle air quantities and static pressure in accordance with the design plus 20%. Air handling units shall be sized for the full connected load with no diversity consideration. Air velocities in branch runs shall be kept low enough to maintain noise levels of NC 25 or less in the room.
  - .2.2.1.2 Provide ceramic bearings on fans controlled by a VFD. Bearing life per Anti-Friction Bearing Manufacturers Association rating procedures shall be 90 percent expectancy of reaching at least 150,000 hours under design conditions.
- .2.8 Terminal Boxes: Terminal boxes shall be provided with fiber free liner with solid sheet metal interior. Terminal boxes shall be pressure independent with hot water reheat coils. Terminal boxes shall be located outside of patient rooms and other patient care procedural rooms for ease of maintenance and accessibility. Control boxes shall be installed where easily accessible. Terminal boxes shall be provided for each individual office, lab, exam room and patient care room unless approved otherwise by OSUMC Facilities Operations.
  - .2.8.1 Labeling: All terminal boxes shall be labeled in accordance with OSUMC requirements. Terminal boxes shall be labeled with TB, building abbreviation, floor and number. For example, a terminal box on the 5<sup>th</sup> floor of Rhodes Hall shall be labeled TB-RH-5-19. Any modifications, deletions or additions within existing buildings shall have the number coordination performed with OSUMC Operations. A color coded dot shall be placed on the ceiling tile grid at the location of the access panel for ease of maintenance.
  - .2.8.2 VAV applications: minimum settings shall be carefully chosen so as not to create excessive negative pressurization and therefore infiltration.

**MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

2007 Edition, Published April 2007

; Division Revision Date: June 30, 2016

.2.8.3 Modification: When modifying systems within existing buildings, confirm design conditions with OSUMC Facilities.

**23 40 00. HVAC AIR CLEANING DEVICES**

.1 REQUIREMENT FOR FILTERS: All air supplied by a forced air type unit or system shall be filtered. Pre-filter and intermediate filter combinations shall be provided upstream from the coils. After-filters shall be on the discharge of the fan and downstream from all coils. Filter size shall be 24"x24" without approval from OSUMC Operations.

Pre- Filter % Efficiency	Intermediate- Filter % Efficiency	After- Filter % Efficiency
30	60	80-95
30	60	95-99
30	60	HEPA

.5 AIR FILTRATION FOR HOSPITALS: Air filtration shall comply with the AIA Guidelines for Design and Construction of Health Care Facilities, latest edition, unless noted differently above.

.8 ELECTRO-STATIC FILTERS shall be prohibited.

.9 HEPA FILTERS:

.9.1 Shall be on air handling units serving operating rooms, all cancer patient rooms, all intensive care rooms.

.9.2 HEPA filter installations shall be tested and certified by a third party testing agent hired by the Associate. Testing for certification shall include a smoke test for leakage and particle count verification. Any deficiencies for certification shall be repaired/replaced by the installing contractor.

**23 50 00. CENTRAL HEATING EQUIPMENT**

**23 57 00 HEAT EXCHANGERS**

.1 SYSTEM DESIGN:

.1.1 The building shall be supplied with a fully redundant heating system, including heat exchangers and pumps. Heat exchangers shall be designed to supply 180-200 degF heating hot water to the building.

.1.2 Heat exchangers shall be steam to hot water converters utilizing shell and tube configuration. The tubes shall be stainless steel.

**23 60 00. CENTRAL COOLING EQUIPMENT**

**MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

2007 Edition, Published April 2007

; Division Revision Date: June 30, 2016

23 60 05. COILS AND PIPING SYSTEMS:

.2 PIPING: Piping for hot and chilled water systems shall include isolation valves, drain valves, air vent facilities and pipe unions at each individual coil as well as its own isolation and balance valves. Air vents (automatic or manual as appropriate) with a line extended to an adjacent floor drain shall be specified for installation wherever air is likely to be trapped. A strainer with isolation valves on the suction side of a pump and a pressure relief valve are required on all systems. Back-flow preventers shall be provided to prevent contamination of potable water systems.

23 64 05. CHILLERS:

.1 Refrigerants shall be coordinated with OSUMC Facilities.

23 65 00. COOLING TOWERS:

.1.6 Provide sump heaters on all cooling towers.

**23 80 10. LIQUID HEAT TRANSFER:**

4 Consideration shall be given to provide 50% propylene glycol in all systems requiring freeze protection.

23 80 17. DESIGN AND INSTALLATION OF STEAM PRESSURE REDUCING STATIONS:

.2 MAIN BUILDING STATIONS: Pressure reducing stations and desuperheaters shall be utilized to reduce the incoming campus steam from 200 psi/585 degF to 70psi/400 degF for utilization to produce heating hot water, domestic hot water, etc. Pressure reducing stations shall be located immediately adjacent to the exterior wall within the building walls, not in a vault.

23 84 00 HUMIDIFIERS:

.1 USAGE: Humidification levels shall be maintained per the requirements of the AIA Guidelines for Design and Construction of Health Care Facilities, latest edition.

.2 DESIGN: Humidifiers shall be direct steam injection. Humidifiers shall be accessible for routine maintenance.

---

END OF DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

## **MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 26 – ELECTRICAL**

2007 Edition, Published April 2007; Revision Date: February 28, 2013

*The special requirements indicated in this appendix shall be incorporated in all Design Documents for Medical Center Projects. These Special Requirements consists of exceptions, revisions or additions to the base Building Design Standards.*

### **26 00 00. ELECTRICAL** 26 00 03. GENERAL PROVISIONS

- .7.21 Setscrew type connectors and couplings are prohibited outdoors only.
- .7.27 Compact fluorescent lamps are acceptable for general illumination by approval from OSUMC Engineering.

### **26 05 05. ELECTRICAL MATERIALS AND METHODS:** 26 05 15. WIRE AND CABLE

- .2.1 See Medical Center Special Requirements for Identification Appendix for specific OSUMC identification guidelines.

### 26 05 17. WIRING DEVICES

- .1 Receptacles located in acute care, clinical or procedural buildings shall be hospital grade. Receptacles located in public areas (e.g., waiting rooms, lobbies, corridors, etc.) shall be tamper-resistant.
  - .1.1.7 Patient care areas shall be tested (and documentation provided) for conformance to NFPA 99 Electrical Systems Performance Criteria and Testing.
  - .1.3.1 Coverplates for flush-mounted standard devices shall be stainless steel only.
  - .1.3.3 Provide all device plates with labeling indicating panel and circuit number (see identification section in appendix).

### 26 05 35. RACEWAYS:

- .1 Control conduit shall also be a minimum of ¾-inch.
- .2.2 Setscrew fittings are acceptable for indoor applications only.

### **26 20 00. LOW-VOLTAGE ELECTRICAL TRANSMISSION** 26 20 03. LOW-VOLTAGE SWITCHGEAR – SERVICE ENTRANCE

- .5 Provide substation interface pull box(es) in substation room to allow for connection to low voltage monitoring systems for breaker information, metering information and any other low voltage contacts (e.g., maintenance switch position indication) as defined below.
- .6 The breaker manufacturer defined communications (BACnet communication protocol if available) bus shall be extended from main and feeder breaker trip units to an externally mounted hinged pull box containing a manufacturer provided gateway (if needed, e.g., Modbus to BACnet) for conversion to BACnet protocol. System communication shall be configured for monitoring purposes only. Coordinate and provide connection to BAS system via Ethernet or MSTP to nearest building controller.

## MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 26 – ELECTRICAL

---

.7 Main breakers shall be equipped with manual override of instantaneous trip unit settings in order to provide acceptable arc flash levels for maintenance work. Manual override position indication shall be monitored by building automation system.

.8 Substation feeder breakers shall not be less than 10% of the rating of the main and tie circuit breaker ratings.

### 26 20 06. GROUNDING SYSTEM:

.7 REFERENCE GROUND POINT: Operating Rooms, procedural rooms, invasive procedure areas that equipotential grounding between multiple sources or grounded equipment and surfaces shall have a reference ground point located within the respective room. The reference ground shall consist of a copper bus mounted inside a dedicated, acceptable enclosure. Utilizing a local power panel ground bus for this purpose is not acceptable.

.8 BUILDING GROUND REFERENCE SYSTEM: Shall consist of an exposed copper bus located in mechanical rooms containing transformers on each floor (one per floor minimum). Grounding system riser drawing detail is required on the construction documents.

### 26 27 05. GENERAL PURPOSE POWER AND LIGHTING CIRCUITS:

.5 For any panelboard (existing that has been modified or new), contractors shall provide both hardcopy and electronic copy of OSUMC panelboard legend standard (in Microsoft Excel format). Template can be provided by OSUMC Facilities Services Department.

.5.1 Refer to Medical Center Appendix E for panel schedule requirements

### 26 30 10. EMERGENCY POWER SYSTEMS:

.2.1 Emergency power generators shall utilize diesel fuel engines.

.2.3 See OSUMC identification standards for coloring and labeling schemes.

.2.4 Emergency Power Supply Systems (EPSS's) in critical care environments shall consist of N+1 power generation redundancy and utilize paralleling switchgear to provide increased reliability. Consideration shall also be given to the use of uninterruptible power supply (UPS) for critical and life safety branches of the emergency power system to eliminate switching interruption. External maintenance bypasses shall be provided to allow for removal and preventative maintenance of any UPS.

.2.5 Provide means for non-invasive connection of load bank to emergency power generators (e.g., spare switch in emergency gear sized for 100% kW rating of generator).

.2.6 Emergency generator electronic control systems shall be monitored via building automation system. If needed, protocol gateways shall be provided to convert generator protocol information to BACnet protocol (e.g., Modbus to BACnet). Provide Ethernet jack in emergency generator locations to allow for connection to BACnet Ethernet backbone.

.2.7 EPSS fuel system shall also be monitored via building automation system. If dry contact indications are furnished with daytank and main fuel tank monitoring systems, provide connection to building automation system.

.3.7 Loads connected the emergency power systems shall be as defined in NFPA 70 for critical, life safety, equipment and delayed equipment branches.



## MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 26 – ELECTRICAL

---

- .3.8 Consideration shall be given quantity of transfer switches and respective loads to allow for load shedding in circumstances of emergency power system diminished capacity.
- .5.1 Transfer switch control panels shall be provided with communications package to allow real time monitoring. Transfer switches shall be monitored via building automation system. If needed, protocol gateways shall be provided to convert generator protocol information to BACnet protocol (e.g., Modbus to BACnet). Provide Ethernet jack in transfer switch locations to allow for connection to BACnet Ethernet backbone.
- .5.2 Delayed transfer switches shall have capability of “0 seconds” transfer time between normal and alternate sources. Those switches with minimum 1 second delay time are not acceptable.
- .5.3 Transfer switches shall be of the bypass isolation type to enable servicing of equipment without shutdown. All bypass-isolation handles/controls shall be externally mounted and not require access into the enclosure for operation. Switches shall be capable of manual operation under load and be quick-make, quick-break. The switch shall have the capability of being fully manually operated and not be dependent upon electrical operators, relays or further interlocks for safe operation.

### **26 50 00. LIGHTING** 26 51 00. INTERIOR LIGHTING

- .1.6 Ballast shall include a maximum Total Harmonic Distortion of 10%.
- .1.7.F. Total harmonic distortion shall be less than 10%.
- .1.8 Battery powered emergency egress lighting, when used, shall be self-diagnosing type (momentary monthly testing and 90 minute annual test). Consideration shall be given to a central battery capable of handling multiple remote heads for those areas with multiple battery powered egress fixtures (e.g., mechanical or emergency power distribution rooms)
- .1.9 Battery ballasts shall be provided with wall mounted, remote testing switches.
- .5 Compact fluorescent lamps: 13W, 18W, 26W 2 or 4-pin, biax lamps (3500K, CRI of 82), 32W triple biax lamps (3500K, CRI of 82) or 40W high lumen biax lamps (3500K, CRI of 82).
- .5.1 Provide brushed aluminum type housing for exit signs.
- .12 Procedure or operating rooms requiring dimming or frequent switching during a procedure shall utilize Lutron Graphic Eye dimming system. System shall utilize Hi-Lume 1% dimming ballasts and be controlled via procedure equipment dry contact closure. Contact closure shall toggle between full “on” and full “dim” to avoid the on/off switching that causes high lamp mortality.
- .13 Procedure or operating room fixtures containing green fluorescent lamps shall utilize ballasts that operate either green or traditional fluorescent lamps. Those ballasts that operate green lamps only are not acceptable.
- .14 Patient rooms with reading and general lighting shall interface with nurse call system. Both general and reading lights shall be controlled individually via both nurse call paddle and room entry momentary toggle switches.
- .15 Corridor, waiting area and lobby lighting in patient care areas shall be controlled from nurse station at a minimum.

## **MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 26 – ELECTRICAL**

---

### 26 58 00. LIGHTING CONTROL

- .2 Exterior lighting control relays shall be controlled via building automation system. If lighting control consists of a system of control relay panels (e.g., Lutron, Lithonia, Delta), they shall be BACnet compliant and interfaced with building automation system.

---

**END OF DIVISION 26 - ELECTRICAL**

## **MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 27 – COMMUNICATIONS**

2007 Edition, Published April 2007

*The special requirements indicated in this appendix shall be incorporated in all Design Documents for Medical Center Projects. These Special Requirements consists of exceptions, revisions or additions to the base Building Design Standards.*

### **27 00 00. COMMUNICATIONS**

#### **27 50 00. DISTRIBUTED COMMUNICATIONS AND MONITORING SYSTEMS**

##### **27 52 23. NURSE CALL/CODE BLUE SYSTEMS**

- .1 SYSTEM ARCHITECTURE: The existing nurse call system consists of multiple General Electric/Dukane ProCare 6000 and Tellingence systems located throughout the OSU Medical Center complex. Each system consists of one main control panel per inpatient floor (typically). Each system communicates via the OSUMC Ethernet network with a common server located in Rhodes Hall Room S540M for pager system, Spectralink system and administrative report monitoring system (ARMS) functions. The ARMS monitoring system is utilized to monitor all events occurring throughout the complex and creates reports for specific user needs. This reporting system is capable of creating reports across multiple buildings and units and can be user modified.
- .2 INPATIENT ROOMS: Each inpatient room shall be provided with a corridor dome light outside of the patient room, a single patient station (located on room entry side of the headwall), a stand alone code blue station on the opposite side of the headwall, a dual 37-pin receptacle located at standard mounting height on the patient headwall, a dual auxiliary input receptacle (for clinical equipment monitoring purposes) located on the headwall, a manual presence station located at room entry point, one lavatory pull station and one shower pull station located in the restroom.
  - .2.1 : The system shall be provided with sealed pillow speakers that allow for nurse call, direct communication with nurse call master station, direct digital control of TV's and control of room lighting (one for general lighting and one for reading light). The lighting control relay shall be separate from the light fixture and mounted above the ceiling near entry to the patient room.
  - .2.2: Provide dummy plugs for all ancillary auxiliary inputs and 37-pin receptacles. Any loose dummy plug needs tethered via a rubberized, bacteria resistant lanyard.
- .3 EXAM ROOMS: Exam rooms shall be provided with (as a minimum) (1) patient station, (1) manual presence station and (1) corridor dome light.
- .4 PROCEDURAL/OPERATING ROOMS: Procedural and operating rooms shall be provided with (as a minimum) (1) staff station, (1) code blue, (1) manual presence station and (1) corridor dome light. Consideration shall be given to additional audible zone lights throughout the procedural space in order to notify staff.
- .5 NURSE STATIONS: Nurse stations shall be provided with base master and video master as a minimum.
- .6 SPARE PARTS: Provide 10% spare parts.

.7 WARRANTY AND TRAINING: Supplier shall provide a minimum (1) year warranty with emergency service applicable. Nurse call system manufacturer or associated local representative shall provide maximum (1/2) hour telephone response and (4) hour site response time for emergency calls during the warranty period. Four (4) hours of training shall be provided per nursing unit.

.8 SERVICE: All service outside of warranty shall be provided under a separate contract

27 53 13. CLOCK AND PROGRAM SYSTEMS:

.1 SUPERVISED CLOCK SYSTEMS: A supervised clock system will be provided only when so required by the building or space program. Supervised clocks shall be digital type only. Clock numbers shall be red, 4" numbers with black aluminum housing. Clock shall be controlled via dedicated data drop with power over Ethernet – no external power supplies shall be required. Clocks will have hour and minute displayed, Clocks needing seconds displayed will be specified by the program.

.1.1 CLOCK AND FIRE ALARM SYSTEMS BIDDING PROCESS: Fire Alarm systems and Supervised Clock systems are viewed by the Medical Center as separate stand-alone systems. They shall not be bid as a combined system by a single manufacturer. Each system shall be bid with a separate cost proposal in projects with Fire Alarm and Supervised Clock systems.

27 53 15. CLASS BELLS:

.1.1 Class Bells will be provided only when so required by the Medical Centers' building program. Class bells are prohibited in Medical Center patient care buildings.

---

END OF DIVISION 27 - COMMUNICATIONS

## MEDICAL CENTER SPECIAL REQUIREMENTS FOR DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

2007 Edition, Published April 2007

Revised February 7, 2017

*The special requirements indicated in this appendix shall be incorporated in all Design Documents for Medical Center Projects. These Special Requirements consists of exceptions, revisions or additions to the base Building Design Standards.*

### **28 00 00. ELECTRONIC SAFETY AND SECURITY**

### **28 10 00. ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION**

28 10 10 ACCESS CONTROL and ALARM MONITORING SYSTEM (ACAMS):

.12 For Ohio State University Wexner Medical Center (OSUWMC) projects equipment to be used on each door application will be determined and approved by the OSUWMC Security management team.

### **PART 1 GENERAL OSUWMC PROJECTS**

- A. The work covered by this section shall include all labor, equipment, materials, and services required to furnish and install a complete network based video surveillance system for the project unless otherwise noted.
- B. All work shall be performed by contractors with a minimum experience of five (5) consecutive years and all their workers shall be certified by the manufacturer.
- C. All work specified shall be an Internet Protocol (IP) based system running on the OSU Department of Public Safety (DPS) Security Systems Management and Coordination (SSMC) network.
- D. Reader licenses and system programming for all licenses and devices to be furnished by KNS Services unless otherwise noted.
- E. The contractor to furnish equipment and configure for Dynamic Host Configuration Protocol (DHCP), and default manufacturer username and passwords. At the end of this section see form that must be filled out.
- F. All locations shall be coordinated with OSUWMC Security management team prior to installation.
- G. All raceways, patch cables, lighting protection (exterior) and wiring shall be installed in accordance with current OSUWMC IT Division 27 specifications.
- H. The system installation shall comply with all other codes and authorities having jurisdiction.

### **.13 MANUFACTURERS FOR OSUWMC PROJECTS**

#### **.13.1 Online POE Sargent Locks**

- A. Sargent Passport 1000 P1 Mortise lock that includes:  
No substitutions / No equals

- a. Utilizes IEEE 802.3af PoE-enabled network infrastructure for both power and data
- b. HID multiClass SE Technology with magnetic stripe reader
- c. No keypad (unless otherwise noted)

B. Power shall be power-over-ethernet (PoE) provided with an electric door transfer hinge.

C. DHCP support shall be provided.

D. A Genetec Synergis Cloudlink may be required for interface with the IP access control system, to be determined by OSUWMC security management.

### .13.2 Online HID GLOBAL

A. HID Edge EVO EH400-K & HID Reader Part #922NWNTKE00C6:  
No substitutions / No equals

- a. HID multiClass SE Technology with magnetic stripe reader
- b. No keypad (unless otherwise noted)
- c. Must be part # 922NWNTKE00C6 for firmware compatibility.

B. Power shall be power-over-ethernet (PoE) for all equipment except locking hardware.

- a. Strike – Powered by POE if 12 volt strike is used.
- b. Strike – Powered by local power supply if 24 volt strike is used.
- c. Magnetic Locks – Powered by local power supply.
  - i. Requires a fire alarm addressable device.
- d. Other – refer to manufacturer specifications.

C. DHCP support shall be provided.

### .13.3 Offline / Standalone WiFi Sargent Locks

A. Sargent Passport 1000 P2 Mortise lock that includes:  
No substitutions / No equals

- a. Utilizes IEEE 802.11 WiFi infrastructure
- b. HID multiClass SE Technology with magnetic stripe reader
- c. No keypad (unless otherwise noted)

B. Power shall be provided by battery.

C. DHCP support shall be provided.

### .13.4 Input / Output Panel

A. Approved Manufacturers:

- a. AXIS P88221
- b. HID GLOBAL EDGE EVO Hi-O Interface Modules
- c. HID GLOBAL VerX V200 / V300 Interface Modules

B. Power shall be power-over-ethernet (PoE) unless otherwise indicated by the manufacturer.

C. DHCP support shall be provided.

## 28 23 23 VIDEO SURVEILLANCE SYSTEMS / CLOSED CIRCUIT TV (CCTV)

### PART 1 GENERAL OSUWMC PROJECTS

- A. The work covered by this section shall include all labor, equipment, materials, and services required to furnish and install a complete network based video surveillance system for the project unless otherwise noted.
- B. All work shall be performed by contractors with a minimum experience of five (5) consecutive years and all their workers shall be certified by the manufacturer.
- C. All work specified shall be an IP based system running on the OSU Department of Public Safety (DPS) Security Systems Management and Coordination (SSMC) network.
- D. CCTV and Reader licenses and system programming for all licenses and devices to be furnished by KNS Services unless otherwise noted.
- E. The Contractor to furnish equipment and configure the Dynamic Host Configuration Protocol (DHCP), and default manufacturer username and passwords. At the end of this section see form that must be filled out.
- F. Final security camera locations are to be functional. Coordinate with other trades to avoid conflict with, but not limited to, light fixtures (obstructions and glare), exposed ductwork, architectural clouds, and FFE, etc. All locations shall be coordinated with OSUWMC Security management team prior to installation.
- G. All raceways, patch cables, lighting protection (exterior) and wiring shall be installed in accordance with the current OSUWMC IT Division 27 specifications.
- H. The system installation shall comply with all other codes and authorities having jurisdiction.
- I. CCTV and other security related equipment shall report all signals to the Medical Center Security Control Center (SCC). Any signal sent out beyond the SCC will be monitored and approved by OSUWMC Management Team.

### .1 MANUFACTURERS FOR OSUWMC PROJECTS

- A. Approved Manufacturers:
  - 1. Bosch
  - 2. Axis
  - 3. Equal equivalent that is certified with OSU's current version of Genetec Security Center.

### .2 PAN-TILT-ZOOM CAMERA DOME CAMERAS

- A. The IP camera dome shall transmit high quality video across the network for remote viewing and recording. It shall be managed by the OSU Network Video Recording Management System (NVRMS).
- B. 2.0 megapixel minimum.
- C. The dome shall use compression based on H.264/MPEG4 that optimizes data and maximizes picture quality.
- D. The dome shall be configurable remotely from the NVRMS.

- E. The Local Area Network (LAN) interface shall be Transmission Control Protocol/User Datagram Protocol /Internet Protocol (TCP/UDP/IP) unicast and multicast.
- F. DHCP support shall be provided.
- G. Adjustment of fps according to network performance capability shall not sacrifice quality.
- H. An embedded self-supported OS shall be provided.
- I. Provide appropriate wall camera enclosures with heater/blower per manufacturer recommendation with mounting brackets (wall, ceiling or corner as required).
- J. Video motion detection shall be provided.

### .3 PANORAMIC INDOOR CAMERA

- A. The IP camera dome shall transmit high quality video across the network for remote viewing and recording. It shall be managed by the OSU NVRMS.
- B. 5.0 megapixel minimum.
- C. The dome shall use compression based on H.264/MPEG4 that optimizes data and maximizes picture quality.
- D. The dome shall be configurable remotely from the NVRMS.
- E. The LAN interface shall be TCP/UDP/IP unicast and multicast.
- F. DHCP support shall be provided.
- G. Adjustment of fps according to network performance capability shall not sacrifice quality.
- H. An embedded self-supported OS shall be provided.
- I. Provide appropriate wall camera enclosures with heater/blower per manufacturer recommendation with mounting brackets (wall, ceiling or corner as required).
- J. Video motion detection shall be provided.

### .4 FIXED POSITION CAMERA DOMES

- A. The IP camera dome shall transmit high quality video across the network for remote viewing and recording. It shall be managed by the OSU NVRMS.
- B. 5.0 megapixel minimum.
- C. The dome shall use compression based on H.264/MPEG4 that optimizes data and maximizes picture quality.
- D. The dome shall be configurable remotely from the NVRMS.
- E. The LAN interface shall be TCP/UDP/IP unicast and multicast.
- F. DHCP support shall be provided.



- G. Adjustment of fps according to network performance capability shall not sacrifice quality.
- H. An embedded self-supported OS shall be provided.
- I. Provide appropriate wall camera enclosures with heater/blower per manufacturer recommendation with mounting brackets (wall, ceiling or corner as required).
- J. Video motion detection shall be provided.

**28 30 00. ELECTRONIC DETECTION AND ALARM**

28 31 00. FIRE DETECTION AND ALARM

.5 SYSTEM ARCHITECTURE: The existing OSUWMC fire alarm system network consist of SimplexGrinnell fire alarm control panels (nodes) of various design releases communicating via Style 7 fiber token ring configuration. All existing OSUWMC buildings currently have at least one addressable node in the building that shall be utilized for expansion and renovation purposes. All panels report to (3) Graphic Command Centers (GCC's) located in the Security Control Room (Rhodes Hall Room S128C), Facilities Services Control Room (Doan Rm 009) and PBX (660 Ackerman Road) via the token ring network. In order to maintain a single, dependable and UL listed monitoring system, it is expected that SimplexGrinnell will be utilized in future expansion.

.5.1 FIBER CONNECTION: The fiber connection in the network shall be 12 strand, multimode fiber extended via 1" conduit between hinged pull boxes located adjacent to each fire alarm panel. The pull box shall contain fiber landing points and fiber jumpers shall be extended to the fire alarm panel. The hinged pull box provides a point of demarcation between IS supported fiber optic cable and the facilities supported fire alarm panel.

.5.2 RACEWAYS: A hinged pull box shall be located on each floor of any multistory building. Each pullbox shall contain terminal strips labeled for IDnet, strobe, speaker, door holder, and 24V DC. Horizontal backbone runs in corridor shall be 1" conduit with a 6"x6" junction box every 30'. Raceway infrastructure facilitates system expansion and troubleshooting.

.6 SYSTEM OVERRIDES: System overrides shall be provided for AHU control, audio circuit, visual circuit, door holder, elevator recall, Matrix/Security panel, fire shutter and lighting system control to enable building testing without impact on building operations.

.7 POINT DESCRIPTORS: Verify point descriptors with OSUMC prior to programming system. Each point requires (at minimum) two letter building designation and room number. Use of architectural corridor numbers is not permitted. Devices in corridors shall be labeled using nearest room as identifier (e.g., corridor by room 235).

.8 WIRING CLASS: For initiating circuits, Class B Style C is acceptable. For notification circuits, Class B Style Y is acceptable.

.9 DEVICES: All smoke sensor devices shall be labeled on the base (not head) with node, channel and device number. This address shall be visible without requiring removal of the head or access into the device.

.10 PULL STATIONS: Pull stations shall be double action.

- .11 DUCT SENSORS: Use of area type smoke detectors in HVAC ducts is STRONGLY discouraged. Remote testing/indication station shall be provided.
- .12 DOOR HOLDER CIRCUITS: 24V door holder circuits shall be installed and drop on floor that is in alarm. One circuit shall not extend between floors.
- .13 SIGNAL DEVICE: Audible and combination audible/visual devices shall be of the speaker type.
- .14 SECURITY PANEL LOCATIONS: Provide fire alarm addressable control device at each security control panel.
- .15 FIRE SHUTTERS: Fire shutters requiring automatic operation shall have (1) smoke sensor with a sounder base on the staff side (if applicable) and (1) smoke sensor with relay base on the public side (if applicable). A 24V DC power supply shall be provided above the ceiling in an accessible location. The normal state for the shutter firefly shall be with applied voltage. The firefly shall have a variable time delay release. Upon either of the (2) smoke sensors activating, the sounder base shall provide an audible warning signal to prior to the relay base activating the release of the shutter. In the event of excessive public traffic, a delay button may be required to allow for clearing of the area under the fire shutter prior to dropping the door (any deviation from code requirements require variance approval). The delay button shall be momentary type, connected to the firefly and parallel the operation of the relay base. Appropriate signage indicating operation of the switch shall be provided with white letters and red background.
- .16 HALON/CHEMICAL SUPPRESSION SYSTEMS: (2) programmable relays shall be provided at the control panel for any Halon or chemical suppression control panels. (1) shall be used for panel trouble indication and (1) for active alarm indication back to building fire alarm panel.
- .17 PRETEST: Prior to any life safety test, contractor and fire alarm manufacturer shall perform a pre-life safety test. Both the contractor and fire alarm manufacturer shall conduct the test under supervision of OSUWMC. The pretest shall be performed at least (3) days prior to any official life safety test in order to allow for system corrections.
- .18 SPARE PARTS: Provide 10% spare parts.
- .19 WARRANTY AND TRAINING: Supplier shall provide a (1) year warranty with emergency service applicable. Fire alarm manufacturer shall provide maximum (1/2) hour telephone response and (4) hour site response time for emergency calls during the warranty period. The amount of training required will vary greatly with the size of the project and extent of the installation.
- .20 SERVICE: All service outside of warranty shall be provided under a separate contract.

---

END OF DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

## MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX A – INSTRUMENTATION AND CONTROL FOR HVAC

---

2007 Edition, Published April 2007

*The Special Requirements indicated in this appendix shall be incorporated in all Design Documents for Medical Center Projects. These Special Requirements consist of exceptions, revisions or additions to the base Building Design Standards.*

### PART 1- GENERAL

#### 1.01 SCOPE

- A. Furnish and install a complete native BACnet DDC Building Automation System (BAS) as manufactured by Delta Controls, Inc. to automatically control the operation of the new HVAC system. The new Building Automation System shall fully integrate into the existing district wide native BACnet Delta Controls virtual private network (VPN). The required integration shall include the creation of custom graphics and the compilation and display of all devices and objects on the existing Delta Controls Operator Workstation (OWS) and Webserver. All graphic displays will reside on the existing Delta Controls OWS and be modified accordingly. In addition, the system shall perform the said integration through the use of BACnet/IP communications (Annex J only). BACnet over Ethernet will not be supported for district wide communications. All integration work shall be performed in cooperation with Delta Controls, Inc. or its local representative. Failure to mention any specific item or device does not relieve the Contractor of the responsibility for installing or integrating such device/peripheral in order to comply with the intent of the Drawings or this Specification.
- B. Proposed Equals shall be proposed as outlined in the Instructions to Bidders, Article 2.5, and as detailed below and must submit product for testing purposes prior to bid. To obtain approval to use unspecified products as 'approved equals', Bidders shall submit written requests to the Associate at least ten (10) working days before the bid date. Requests received after this time will not be considered. Requests shall clearly describe the system for which approval is asked, including all data necessary to demonstrate that it meets all performance requirements of the specifications. This data shall include but is not limited to, Protocol Implementation Conformance Statements, Device Profile listings, BIBB Summaries and Read/Write documentation (all similar to what is listed under this specification). If the proposed equal is found to be acceptable, an addendum will be issued, as outlined in the Instructions to Bidders, Article 2.5, to all contractors on record. Submitted data shall be organized, tabulated, and annotated as follows:
  1. Overall table of contents
  2. Individual table of contents for each section
  3. Tabulated list of included hardware and software (differentiated from available-but-not-included hardware and software)
  4. Tabulated list of conformance to each paragraph of this specification, listing any exceptions thereto
  5. Specific description of hardware, firmware, and software as proposed
  6. Campus-wide Ethernet network diagram applicable to this project
  7. Auto-dial/auto-answer communications network

8. Building-wide peer-to-peer Building Controller network diagram
9. Advanced Application Controller local area network diagram
10. Detailed description of graphic and display software characteristics
11. Detailed description of DDC control software characteristics
12. BACnet Compliance Documentation

C. Building Automation System (BAS) Contractor shall provide:

1. A fully integrated and fully programmable BACnet building automation system (BAS), UL listed (UL916 and UL864 If applicable), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, as manufactured by Delta Controls. The use of algorithmic or canned programming controllers will not be permitted. A UL864 listing shall be required for all controllers that are utilized in a smoke control sequence and as necessary to meet or exceed all national and local codes. In addition, UL864 devices and non UL864 shall not be permitted on the same network segment unless the devices are separated with a UL864 Ethernet switch. All MS/TP network segments shall be consistent with its UL864 or non UL864 implementation. In other words, there shall not be UL864 product and non UL864 product on the same MS/TP network segment.
2. Necessary conduit, wiring, enclosures, and panels, for all DDC temperature control equipment and devices. Installation shall comply with applicable local and national codes.
3. All components and control devices necessary to provide a complete and operable DDC system as specified herein.
4. All final electrical connections to each stand-alone DDC Controller. Connect to 120VAC power as provided by the Division 26 contractor, to be terminated within 5 feet of the DDC Controller.
5. BAS Contractor shall be responsible for all electrical work associated with the BAS control system and as called for on the Drawings. This BAS control wiring shall be furnished and installed in accordance with the Electrical requirements as specified in Division 26, the National Electric Code, and all applicable local codes.
6. Surge transient protection shall be incorporated in design of system to protect electrical components in all Building Controllers, Advanced Application Controllers and operator's workstations. Provide an external protection device listed under UL 1449 with minimum clamping voltage of 130 VRMS and surge current capability of 22,500Amps for all custom fabricated control panels (all main system components (i.e, AHUs, Chillers, Boilers, etc.).
7. All 120V and low voltage electrical control wiring exposed throughout the building shall be run in conduit in accordance with the Electrical requirements as specified in Division 26, the National Electric Code, and all applicable local codes. All low voltage wiring that is concealed in accessible ceilings may be run in plenum rated cable per the National and Local Electrical codes.
8. All 24VAC power required for operation of the BAS shall be by the BAS Contractor and shall be limited to 100 VA per the aforementioned codes. Any 24VAC power link that exceeds the 100 VA rating must be installed in conduit per Division 26 and all applicable

codes, regardless of the nature of the installation.

9. BAS Contractor shall provide programming modifications necessary to fine tune sequences during commissioning and through the warranty period of system and for an additional 12 months, at no extra cost to The Ohio State Medical Center.

D. HVAC Contractor provides:

1. All wells and openings for water and air monitoring devices, temperature sensors, flow switches and alarms furnished by BAS Contractor.
2. Installation of all control valves as per the contract drawings. The temperature control contractor is not responsible for the incorrect installation of any domestic, hot or chilled water control valves.
3. Installation of all dampers and adjacent access doors for smoke; outdoor air, return air, exhaust air, and ventilation dampers.
4. All package unit control panels including but not limited to, factory boiler panels, factory chiller panels, refrigerant monitors and specialty interface modules required for BACnet compliance.

E. Electrical Contractor provides:

1. Electrical Contractor shall provide dedicated 120 volt, 20 amp circuits and circuit breakers from normal and/or emergency power panel for each DDC Controller. Run power circuit within 5 feet of equipment installed and connected by BAS Contractor.
2. Electrical contractor will also provide smoke detector and smoke damper interlock and power wiring for all life safety applications.

F. General Product Description:

1. The building automation system (BAS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection utilizing the BACnet protocol.
2. The building automation system shall consist of the following:
  - a. Stand-alone peer-to-peer Building Controllers with 32 bit processors, a minimum of 2 MB of flash memory and 10 bit A/D converters. Ethernet connectivity is required for all Building Controllers.
  - b. Stand-alone peer-to-peer Advanced Application Controllers with 32 bit processors, a minimum of 1 MB flash memory and 10-bit A/D converters. Ethernet or MS/TP connectivity will be permitted for all AACs.
  - c. Portable operator's terminal(s)
  - d. Provide seamless interconnection to the existing Delta Controls central graphic workstation, and build Delta Controls standard and HTML / ASP customized graphics displays in accordance with the existing formats.
3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Building Controllers, Advanced

Application Controllers, expansion modules and operator devices.

4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices. Alarm management and data collection that requires a single mechanism for user notification or viewing is strictly prohibited.
5. All Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central processing device (peer-to-peer). All Controllers shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

## 1.02 RELATED WORK

### A. Specified elsewhere:

1. \_\_\_\_\_ - Sequence of Operation
2. \_\_\_\_\_ - Variable Speed Control
3. \_\_\_\_\_ - Basic Mechanical Requirements
4. \_\_\_\_\_ - Motors
5. \_\_\_\_\_ - HVAC Pumps
6. \_\_\_\_\_ - Boilers
7. \_\_\_\_\_ - Chillers
8. \_\_\_\_\_ - Cooling Tower
9. \_\_\_\_\_ - Terminal Heat Transfer Units
10. \_\_\_\_\_ - Air Handling Units
11. \_\_\_\_\_ - Testing, Adjusting and Balancing
12. \_\_\_\_\_ - Basic Electrical Materials and Methods
13. \_\_\_\_\_ - Equipment Wiring

### B. Materials furnished by the BAS contractor, but installed by others:

1. BAS Contractor to furnish the following to the Heating, Ventilation and Air Conditioning Contractor for installation by the HVAC contractor:
  - a. Control valves and temperature sensor wells for wet systems
  - b. Location of all wells and openings for temperature, pressure, and flow sensors for pipe systems

- c. Control dampers for air systems
- d. Variable Frequency Drives
- e. Location of all ducts and openings for temperature, pressure, flow, and humidity sensors for air systems.

### 1.03 QUALITY ASSURANCE

- A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- B. Install system using competent workmen who are fully trained and factory certified in the installation of temperature control equipment. The factory certified diplomas shall be readily available at the request of the owner or associate engineer.
- C. Single source responsibility of supplier shall be the complete installation and proper operation of the BAS and control system and shall include debugging and proper calibration of each component in the entire system. The BAS must be supplied and installed by the same control contractor. Only Factory Authorized Distributors will be considered for installation. The letting of separate contracts by the prime HVAC Contractor for the Control System and a separate contract for its installation by a third party installer is strictly prohibited.
- D. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
- E. All electronic equipment shall conform to the requirements of FCC Regulations, Part 15, Subpart B, Class A, governing radio frequency electromagnetic interference, and be so labeled.
- F. BAS shall comply with, and be listed at time of bid for the following Underwriters Laboratories Standards:
  - 1. UL 916 for Energy Management Equipment, per category PAZX for Energy Management Equipment.
  - 2. UL 864 for Control Units for Fire-Protective Signaling Systems, per category UUKL for Smoke Control System Equipment.
- G. Product shall be ISO 9001 Registered at the time of bid.
- H. Design and build all system components to be fault-tolerant.
  - 1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3-Hertz variation in line frequency.
  - 2. Static, transient and short-circuit protection on all inputs and outputs.
  - 3. Protect communication lines against incorrect wiring, static transients and induced magnetic interference.
  - 4. Network-connected devices to be AC-coupled or equivalent so that any single device failure will not disrupt or halt network communication.
  - 5. All Building / System Controllers shall have real time clocks and data file RAM with

battery and SRAM backup.

6. All controllers shall be EEPROM, flash driven.
7. The BAS Installer shall have a competent and factory certified Project Manager who is able to answer field questions, is aware of all schedules and schedule changes, and is responsible for the BAS Installer's work and the coordination of their work with all other trades. This Project Manager shall be available for on site and shall respond to design, programming, and equipment related questions. Failure to provide the above services shall be considered a substantial breach of Contract Documents.

#### 1.04 SUBMITTALS

- A. Submit 10 complete sets of drawings showing the kind of control equipment for each of the various systems and their functions, along with indications on the drawing of all original setpoints and calibration values, and setup parameters, and sequence of operation of the automation system. These drawings shall be submitted for approval to the Associate, together with a complete brochure describing the equipment and their functions and operation. Include all application software documentation (actual programs or their job-specific flow charts) with DDC system and schedule a review meeting with OSU and the Associate at least two weeks before installation and start up.
  1. Manufacturer's Product Data:
    - a. All equipment components
  2. Shop Drawings:
    - a. System wiring diagrams with sequence of operation for each system as specified.
    - b. Submit manufacturer's product information on all hardware items along with descriptive literature for all software programs to show compliance with specifications.
    - c. System configuration diagram showing all panel types and locations as well as communications network and workstations.
- B. Where installation procedures, or any part thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Associate prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

### **PART 2- PRODUCTS**

#### 2.00 BACnet CONFORMANCE

- A. The Building Automation System (BAS) contractor shall supply a BACnet (ANSI/ASHRAE 135-2004) compliant system. Each device category and its required compliance are listed below under sections F-H. BACnet compatible systems that employ the use of proprietary 'gateways' will not be accepted unless otherwise noted. All non-approved BAS Contractors shall supply, prior to bid, Protocol Implementation Conformance Statements (PICS), BACnet Interoperability Building Block (BIBB) summaries or Device Profile listings and a detailed listing of Read/Write capabilities to the Associate Engineer for final approval (see proposed equals).



- B. The BACnet system shall be capable of Internet Protocol (IP) communications. BACnet/IP or Annex J will be considered the basis of design. All other configurations must be submitted prior to bid, in writing, for final approval. These configurations shall include but not limited to, Annex H or third party BACnet tunneling routers.
- C. The primary Local Area Network (LAN) shall be based upon the ISO 8802-3 Ethernet standard and will be required for all Building Controllers, System Controllers and Operator Work Stations. The use of MS/TP communications for interconnecting the said devices is strictly prohibited. The installation of all Ethernet wiring, accessories, and connectors shall conform to the ISO standard and/or guidelines identified herein. The preferred connection media shall be Category 6, Unshielded Twisted Pair (UTP) wire. The maximum single network run shall not exceed more than 300 feet. If additional distance is needed, the use of switches (not hubs) or other Ethernet medias will be acceptable. However, the 'cascading' of more than 3 switches on a single segment will not be accepted. The BAS system may utilize the customer's Local Area Network (LAN) provided the bandwidth consumption is less than 10% of the total network bandwidth. Under no circumstances, shall the customer's LAN be subject to failure and/or abuse. In efforts to decrease liability, all BACnet devices that reside on the LAN must support the BACnet Broadcast Management Device (BBMD) scheme. Multi-casting or Global broadcasting will not be permitted without the use of a BBMD. The Ohio State Medical Center will require one BBMD device for every floor of every building. The Medical Center network will be segmented so that each floor will be a separate subnet from all others.
- D. The secondary or sub-network shall utilize the Master-Slave/Token-Passing protocol, as acknowledged by the ANSI/ASHRAE 135 standard. Proprietary RS-485 or equivalent links will not be considered unless otherwise noted. The MS/TP link shall operate at a 76.8 Kbps minimum, and utilize no more than 2 repeaters in any instance. Multi channel repeaters will not be permitted.
- E. The use of proprietary gateways to transmit input/output data, and/or related information, must reside on the Ethernet LAN and be approved, in writing, prior to the bid.
- F. **Workstation conformance (OWS):** The workstation must be scheduled or submitted to the BTL for future testing, under Device Profile B-OWS (Annex L of the BACnet standard) with support of the following BIBBs:

Alarm and Event Management BIBBs

AE-ACK-A, AE-ACK-B, AE-ASUM-A, AE-ASUM-B, AE-ESUB-A, AE-ESUM-B, AE-INFO-A, AE-INFO-B, AE-N-A, AE-N-E-B, AE-N-I-B

Device Management BIBBs

DM-BR-A, DN-DCC-A, DM-DCC-B, DM-DDB-A, DM-DDB-B, DM-DOB-A, DM-DOB-B, DM-LM-A, DM-LM-B, DM-OCD-A, DM-OCD-B, DM-RD-A, DM-RD-B, DM-TM-B, DM-TS-A, DM-UTC-A

Data Sharing BIBBs

DS-COV-A, DS-COV-B, DS-COVU-A, DS-COVU-B, DS-RP-A, DS-RP-B, DS-RPM-A, DS-RPM-B, DS-WP-A, DS-WP-B, DS-WPM-A, DS-WPM-B

Network Management BIBBs

NM-CE-A, NM-CE-B

Scheduling BIBBs

SCHED-A, SCHED-E-B, SCHED-I-B

Trending

T-ATR-A, T-ATR-B, T-VMT-A, T-VMT-E-B, T-VMT-I-B

- G. **Building Controller Conformance (BC):** The building controller must be certified and listed by BTL (BACnet Testing Laboratory) under Device Profile B-BC (Annex L of the BACnet standard) with support of the following BIBBs:

Alarm and Event Management BIBBs

AE-ACK-B, AE-ASUM-B, AE-ESUM-B, AE-INFO-B, AE-N-A, AE-N-E-B, AE-N-I-B

Device Management BIBBs

DM-BR-B, DM-DCC-B, DM-DDB-A, DM-DDB-B, DM-DOB-A, DM-DOB-B, DM-OCD-B, DM-RD-B, DM-TM-A, DM-TS-A, DM-TS-B, DM-UTC-A, DM-UTC-B

Data Sharing BIBBs

DS-COV-A, DS-COV-B, DS-COVU-A, DS-COVU-B, DS-RP-A, DS-RP-B, DS-RPM-A, DS-RPM-B, DS-WP-A, DS-WP-B, DS-WPM-B

Network Management BIBBs

NM-CE-A, NM-CE-B

Scheduling BIBBs

SCHED-A, SCHED-E-B, SCHED-I-B

Trending

T-ATR-B, T-VMT-E-B, T-VMT-I-B

- H. **Advanced Application Controller Conformance (AAC):** The AAC must be certified and listed by BTL (BACnet Testing Laboratory) under Device Profile B-AAC (Annex L of the BACnet standard) with support of the following BIBBs:

Alarm and Event Management BIBBs

AE-ACK-B, AE-ASUM-B, AE-ESUM-B, AE-INFO-B, AE-N-E-B, AE-N-I-B

Device Management BIBBs

DM-BR-B, DM-DCC-B, DM-DDB-A, DM-DDB-B, DM-DOB-A, DM-DOB-B, DM-LM-B, DM-OCD-B, DM-RD-B, DM-TM-A, DM-TS-B, DM-UTC-B

Data Sharing BIBBs

DS-COV-A, DS-COV-B, DS-COVU-A, DS-RP-A, DS-RP-B, DS-RPM-A, DS-RPM-B, DS-WP-A, DS-WP-B, DS-WPM-B

Network Management BIBBS

NM-CE-A

Scheduling BIBBs

SCHED-E-B, SCHED-I-B

Trending

T-ATR-B, T-VMT-E-B, T-VMT-I-B

- I. **Application Specific Controllers (ASC):** ASCs will not be permitted on this project. The minimum level BACnet Controller that will be accepted by The Ohio State University Medical Center shall be listed as a B-AAC device under the BTL certification process.
- J. **Read / Write Properties:** The entire BACnet BAS system (all OWS, BC, AAC and ASC devices) shall support the following Read/Write properties within the given BACnet objects and shall permit dynamic creation and deletion thereof.

Analog Input Object

Read and Write Properties: Description, Name, Value, COV Increment, Out of Service, Reliability

Read Only Properties: Type, Units, Status Flags, Event State

Analog Output Object

Read and Write Properties: Description, Name, Value, Out of Service, Reliability

Read Only Properties: Type, Units, COV Increment, Status Flags, Event State, Priority Array

Analog Variable Object

Read and Write Properties: Description, Name, Value, Units, COV Increment, Out of Service, Reliability

Read Only Properties: Type, Status Flags, Event State

Binary Input Object

Read and Write Properties: Description, Name, Value, Out of Service, Reliability

Read Only Properties: Type, Status Flags, Event State

Binary Output Object

Read and Write Properties: Description, Name, Value, Out of Service, Reliability, Minimum On/Off time

Read Only Properties: Type, Status Flags, Event State, Priority Array

Binary Variable Object

Read and Write Properties: Description, Name, Value, Out of Service, Reliability

Read Only Properties: Type, Status Flags, Event State

Event Enrollment Object

Read and Write Properties: Description, Name, Notification Class, Event Enable, Event Parameter, Event Type, Object Reference

Read Only Properties: Type, Event State, Event Time Stamps, Notification Type, Acknowledged Transactions

Notification Class Object

Read and Write Properties: Description, Name, Priority, Recipient List

Read Only Properties: Type, Notification Class

Calendar Object

Read and Write Properties: Description, Name

Read Only Properties: Type, Value

Schedule Object

Read and Write Properties: Description, Name, Object Reference, Weekly Schedule, Effective Period, Schedule Exceptions

Read Only Properties: Type, Value

Trendlog Object

Read and Write Properties: None

Read Only Properties: Description, Name, Type, Notification Class, Event Enable, Event State, Event Time Stamps, Notification Type, Acknowledge Transactions, Log Enabled, Start/Stop Time, Log Interval

Program Object

Read and Write Properties: Description, Name, Out of Service, Reliability, Program Change

Read Only Properties: Type, Status Flags

Loop Object

Read and Write Properties: Description, Name, Value, COV Increment, Out of Service, Reliability, Tuning Parameters, Action, Controlled Variable

Read Only Properties: Event State, Status Flag, Type

File Object

Read and Write Properties: Description, Name

Read Only Properties:                      Type

## 2.01 NETWORKING COMMUNICATIONS

- A. The design of the BAS network shall integrate operator workstations and stand-alone DDC Controllers on a peer-to-peer communications network, and other devices on other networks. The network architecture shall consist of the following four levels:
1. A district-wide Ethernet communications network based on the BACnet/IP protocol (Annex J.)
  2. An auto-dial/auto-answer BACnet PTP telecommunications network.
  3. A building-wide peer-to-peer communications network between Building Controllers utilizing the BACnet protocol over Ethernet media.
  4. BACnet MS/TP secondary networks extended from appropriate Building Controllers to associated Advanced Application Controllers.
- B. Access to system data shall not be restricted by the hardware configuration of the building automation system. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.
- C. District-wide Ethernet Communications Network (Primary Connection)
1. Local within this building, provide one Ethernet link between the campus-wide BACnet/IP virtual network and the building-wide peer-to-peer network (Building Controller network). Only one peer-to-peer Building Controller per floor shall provide the interface to the BACnet/IP virtual network for remote monitor, remote manual control, remote alarm, and remote programming of sequences of any and all building-wide points (BBMD device).
  2. Remote at the Central Utilities office (Room 009), provide one Ethernet link for monitor, control, alarm, displaying graphics, and simultaneous programming of sequences. If programming of sequences cannot be accomplished simultaneously while performing monitor, control, alarm, and displaying graphics, then provide a second Ethernet link to allow for simultaneous programming.
  3. All Ethernet communications shall include software management and control for both access and privilege. The remote Central Utilities office shall manage all rights for access and privilege per each remote location, for remote monitor, remote manual control, remote alarm, and remote programming of sequences of any and all building-wide points.
- D. Auto-dial/Auto-answer Telecommunication Network (Secondary connection):
1. BACnet PTP communications shall be provided to allow Building Controllers to communicate with remote operator stations and/or remote terminals on an intermittent basis via telephone lines, as indicated in the sequence of operations.
  2. Auto-dial Building Controllers shall automatically place calls to workstations to report alarms or other significant events.
    - a. Building Controllers shall be able to store a minimum of 20 phone numbers of at

least 20 digits. Retry a single primary number at a fixed interval until successful.

- b. The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers. Provide as a minimum 3 secondary numbers when communications cannot be established with the primary device.
  3. Operators at dial-up workstations shall be able to perform all control functions; all report functions and all database generation and modification functions as described for workstations connected via the network. Routines shall be provided to automatically answer calls from remote Building Controllers. The fact that communications are taking place with remote Building Controllers over telephone lines shall be completely transparent to an operator.
    - a. An operator shall be able to access remote buildings by selection of any facility by its logical name. The workstation dial-up program shall store the phone numbers of each remote site, so the user shall not be required to remember or manually dial telephone numbers.
    - b. A PC workstation may serve as an operator device on a network, as well as a dial-up workstation for multiple auto-dial DDC Controllers or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with network activity, nor shall network activity keep the workstation from handling incoming calls.
  4. Dial-up communications shall make use of Hayes compatible modems and voice-grade telephone lines. Provide modems rated at 56K baud with auto ranging. System access to be provided through phone lines to the existing campus Front End Computer. If applicable, the cost of the phone line installation is the responsibility of this contractor and should be included in this contract.

E. Building-wide Peer-to-Peer Communications Network:

1. Operator workstations and Building Controllers shall directly reside on an Ethernet network such that communications may be executed directly between Building Controllers and workstations on a peer-to-peer basis, without requirement for any device to operate or manage the network. A portion of the network management is built into each of the 'peer-to-peer members. 'Peer-to-peer' refers to controllers that (when interconnected) will act independently as equals, without a network manager, and will communicate in a token passing protocol with each other to pass data packet information for the purpose of building-wide monitoring and control. A special data packet called the 'token' is constantly and continually 'passed' to every member of the peer-to-peer communications network. Any peer-to-peer device on the network can send a packet of data only when it has the 'token'. Any peer-to-peer device on this network can request data from, or send data to, any other device on the network. With this procedure, token ensures that data collisions do not occur, and assures that all members of the network get equal opportunity for all data on the network.
2. Systems that operate via polled response or other types of protocols that rely on a network manager, file server, or similar device to manage panel-to-panel communications will not be considered.
3. All operator devices either resident on the peer-to-peer network, or connected via dial-up modems shall have the ability to access all point status and application report data or

execute control functions for any and all other devices via the peer-to-peer network. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the peer-to-peer network data.

4. Network design shall include the following provisions:
  - a. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. System performance shall ensure that an alarm occurring at any DDC Controller is displayed at workstations and/or alarm printers within 5 seconds.
  - b. Support of any combination of DDC Controllers and operator workstations directly connected to the peer-to-peer network. A minimum of 50 devices shall be supported on a single network (including MS/TP).
  - c. Message and alarm buffering to prevent information from being lost.
  - d. Error detection, correction and retransmission shall be included to guarantee data integrity.
  - e. Synchronization of real-time clocks, to include automatic daylight savings time updating between all controllers shall be provided. Universal Time Coordinate based upon Greenwich Mean Time must be supported. (All BC devices must have Real Time Clocks with battery and SRAM backup, see section 1.03 H)
5. Acceptable protocols for intercommunications between building-wide peer-to-peer Building Controllers:
  - a. BACnet over Ethernet (BACnet/IP between subnets only)

F. Local Area (communications) Network (LAN):

1. This communications network shall be limited to Building Controllers and Advanced Application Controllers and shall communicate bi-directionally with the BACnet peer-to-peer network.
2. Advanced Application Controllers shall be arranged on the LAN's in a functional relationship to the corresponding Building Controllers. For example, a VAV Advanced Application Controller serving a VAV terminal box shall be connected on a MS/TP network from the Building Controller that is controlling the corresponding air handling unit.
3. A maximum of 64 Advanced Application Controllers may be configured on any individual LAN from any Building Controller to insure adequate global data and alarm response times.
4. Acceptable protocols for intercommunications between Advanced Application Controllers and Building Controllers, are as follows:
  - a. BACnet (MS/TP), BACnet over Ethernet

2.02 BUILDING CONTROLLER

- A. DDC (stand-alone) Controllers shall have a 32 bit processor with EEPROM, flash driven operating system (OS). They shall also be multi-tasking, multi-user, real-time digital control processors and permit I/O expansion for control / monitoring of up to 48 I/O. Controller size shall be sufficient to fully meet the requirements of this specification.
- B. Each Building Controller shall have sufficient flash memory (EEPROM), a minimum of 2 megabyte, to support its own operating system. In addition, there shall be additional SRAM memory for database handling: Both the EEPROM and SRAM shall permit full implementation and support of all B-BC requirements of this specification, including:
  - 1. Control processes
  - 2. Energy management applications
  - 3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
  - 4. Historical/trend data for points specified
  - 5. Maintenance support applications
  - 6. Custom processes
  - 7. Operator I/O
  - 8. Dial-up communications
  - 9. Manual override monitoring
- C. Each Building Controller shall support:
  - 1. Monitoring of the following types of inputs, without the addition of equipment outside of the Building Controller cabinet:
    - a. Analog inputs
      - 1) 4-20 mA
      - 2) 0-10 Vdc
      - 3) Thermistors
    - b. Digital inputs
      - 1) Dry contact closure
      - 2) Pulse Accumulator
      - 3) Voltage Sensing
  - 2. Each Building Controller shall be capable of providing the following control outputs without the addition of equipment outside the Building Controller cabinet:
    - a. Digital outputs (contact closure)
      - 1) Contact closure (motor starters, up to size 4)
    - b. Analog outputs



- 1) 4-20 mA
- 2) 0-10 Vdc
- 3) 0-135 Ohm (with external Transducer)

- D. Each Building Controller shall have a minimum of 10 percent spare (panel real estate) capacity for future point connection and shall support up to 48 I/O with modular expansion modules. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than two spares of each implemented I/O type. Provide all processors, power supplies, database memory, program sequence memory, and communication controllers complete so that the implementation of any added point (within the above 10% spare) only requires the addition of the appropriate point input/output termination module, point sensor, and wiring.
1. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.
  2. Building Controllers shall provide at least one RS-232C serial data communication ports (BACnet PTP compatible) for operation of operator I/O devices such as industry standard printers, operator terminals, modems and laptop portable operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals. System-wide access must be provided at each mechanical equipment room through the local Building Controller. Panel mounted terminals are not required. Furthermore, all Building Controllers shall include a hardwired, concealed and secured, RJ-11 or RJ-45 jack for use by the Portable Operators Workstation. The local operator, using the Portable Operators Workstation, shall plug into this jack, and shall perform all monitoring, control, and programming of sequences for any and all building-wide points and sequences while standing at any Advanced Application Controller.
- E. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the Building Controller via local, point discrete, on-board supervised hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points. These override switches shall be operable whether the panel processor is operational or not.
1. Switches shall be supervised and mounted either within the Building Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.
  2. Building Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. Building Controllers shall also collect override activity information for reports.
- G. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LED's or analog indication of value shall also be provided for each analog output.
- H. Each Building Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The Building Controller shall provide both local and

remote annunciation of any detected component failures and for repeated failure to establish network communications.

- I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point termination's to suppress induced voltage transients consistent with current IEEE Standard C62.41.
- J. In the event of the loss of normal power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Programs residing in memory shall be protected either by using EEPROM under capacitor backup or by an uninterruptible power source (battery backup). The backup power source shall have sufficient capacity to maintain volatile memory in event of an AC power failure. Where interruptible power source is rechargeable ( a rechargeable battery), provide sufficient capacity for a minimum of seventy-two hours backup. Charging circuitry, while the controller is operating under normal line power, shall constantly charge the rechargeable power source. A non-rechargeable power source shall not be permitted. Batteries shall be implemented to allow replacement without soldering.
  - 1. Upon restoration of normal power, the Building Controller shall automatically resume full operation without manual intervention.
  - 2. Should Building Controller memory be lost for any reason, the user shall have the capability of reloading the Building Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
- K. Building Controllers must comply with Section 2.02, A-J and 2.03. Panels that lose communication or control due to a single sensor failure are not permitted.
- L. Building Controllers will be used in each equipment room where major or more than two pieces of equipment are being controlled. The use of AAC or ASC devices for critical or main system equipment will not be permitted.
- M. All points associated with a given mechanical system (i.e., an air handling unit) will be controlled from a single Building Controller or point expansion panels from the respective master. (i.e., remote motor control centers). No points from a given mechanical system may be distributed among multiple panels - points must be run back to a single Building Controller dedicated to that mechanical system. Closed-loop control must never depend upon network communications. All inputs, program sequences, and outputs for any single DDC control loop shall reside in the same Building Controller.

### 2.03 BUILDING CONTROLLER RESIDENT SOFTWARE FEATURES

- A. General:
  - 1. All necessary software to form a complete operating system as described in this specification shall be provided.
  - 2. The software programs specified in this Section shall be provided as an integral part of Building Controllers and shall not be dependent upon any higher level computer for execution.
  - 3. Point naming convention shall be as referenced in Appendix A (see end of section). The BC shall support a 128 character object name length. BCs that only permit a 32 character length will not be permitted.

B. Control Software Description:

1. The Building Controllers shall have the ability to perform any or all of the following pre-tested control algorithms:
  - a. Two-position control
  - b. Proportional control
  - c. Proportional plus integral control
  - d. Proportional, integral, plus derivative control
2. Control software shall include a provision for limiting the number of times that each piece of equipment may be cycled within any one-hour period.
3. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. This feature shall be resident in all Binary Output objects. The use of custom programming to prevent an excessive demand on start-up shall not be required.
4. Upon the resumption of normal power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

C. All programs shall be executed automatically without the need for operator intervention and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Sequence of Operations. Building Controllers shall have the ability to perform any or all of the following energy management routines:

1. Time-of-day scheduling
2. 365 day Calendar-based scheduling
3. Holiday scheduling
4. Temporary schedule overrides
5. Start-Stop Time Optimization
6. Automatic Daylight Savings Time Switch over
7. Night setback control
8. Enthalpy switch over (economizer)
9. Peak demand limiting
10. Temperature-compensated duty cycling
11. Fan speed/ control
12. Heating/cooling interlock

13. Cold deck reset
14. Hot deck reset
15. Hot water reset
16. Chilled water reset
17. Condenser water reset
18. Chiller sequencing
19. Chiller load monitoring

D. Building Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. It shall be possible to use any of the following in a custom process:
  - a. Any system measured point data or status
  - b. Any calculated data
  - c. Any results from other processes
  - d. User-defined constants
  - e. Arithmetic functions (+, -, \*, /, square root, exponential, etc.)
  - f. Boolean logic operators (and/or, exclusive or, etc.)
  - g. On-delay/off-delay/one-shot timers
2. Custom processes may be triggered based on any combination of the following:
  - a. Time interval
  - b. Time-of-day
  - c. Date
  - d. Other processes
  - e. Time programming
  - f. Events (e.g., point alarms)
3. A single process shall be able to incorporate measured or calculated data from any and all other controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other controllers on the network.
4. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or

pager.

5. The custom control programming feature shall be compiled and documented via English language descriptors. These descriptors (comment lines) shall be viewable from local operator I/O devices to facilitate troubleshooting.
- E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Building Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator activity at a PC workstation, local I/O device or communications with other panels on the network.
1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
  2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each Building Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
  3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs.
  4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
    - a. Each Building Controller shall be capable of storing all custom alarm text for each alarm. The alarm text shall be unique and user defined; custom text shall be available for all BACnet alarms and shall reside in the BC, not in an OWS or PC.
    - b. Alarms shall have ability to be acknowledged from the local operator I/O device, (once the problem is resolved).
  5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.
- F. A variety of historical data collection utilities shall be provided for manual or automatic sampling, storing and displaying system data for points as specified in the I/O summary.
1. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
    - a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controller. Two methods of collection shall be allowed; either by a pre-defined time interval, or upon a pre-defined change of value. Sample intervals of 1 second to 7 days shall be provided. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of

storing a minimum of 10,000 data samples.

2. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either; user-defined interval, manual command, or automatically when the trend buffers are full. Furthermore, the workstation shall notify the end-user if the hard drive capacity is low or if the database size is excessive. The OWS shall use a standard MSDE or SQL database handler for all trend log management. All trend data shall be available to all BACnet OWSs and for use in 3rd party personal computer applications. File format type to be comma delineated.
  3. Building Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary. Provide capability to view or print trend and tuning reports.
    - a. The Loop object shall display the most recent historical data of its own performance. It shall illustrate the number of setpoint crossings and the maximum and average deviation from setpoint.
    - b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
- G. Building Controllers shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary.
1. The totalization routine shall have a sampling resolution of one minute or less.
  2. The user shall have the ability to define a warning limit for run-time totalization. Unique, user-specified messages shall be generated when the limit is reached.
- H. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/O summary.
1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g., kWh, gallons, BTU, tons, etc.).
  2. The totalization routine shall have a sampling resolution of one minute or less.
  3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
- I. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for points as specified in the point I/O summary.
1. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.
  2. The user shall have the ability to define a warning limit. Unique, user-specified messages, up to 200 characters, shall be generated when the limit is reached.

J. Advanced Application Controllers:

1. Each Building Controller shall be able to extend its performance and capacity through the use of remote Advanced Application Controllers. Each Advanced Application Controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Advanced Application Controller shall be a microprocessor-based, 32 bit, multi-tasking, real-time digital control processor. Provide for control of terminal equipment including, but not limited to, the following:
  - a. Rooftop units
  - b. VAV Boxes
  - c. Heatpumps
  - d. Fancoils, Univents
  - e. Other terminal equipment or monitoring
2. Advanced Application Controllers must comply with Section 2.03, items A through I, and must be peer-to-peer devices. Advanced Application Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden. Switches will only be required for non-terminal applications or where controllers are readily accessible (not required for VAVs, Heatpumps, etc. that are above ceilings or inaccessible). All inputs and outputs shall be of the Universal type, allowing for additional system flexibility. A minimum of 12 global points (i.e. chilled water temperature, hot water temperature, etc.) must be able to be accessed through the Advanced Application Controller. If global point access is unavailable with the Advanced Application then a Building Controller must be furnished.
3. Each Advanced Application Controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event that communication with its Building Controller is lost and to insure protection during power outages. In the event that the AAC does not support a real time clock (RTC) function and it is being used on critical or system level equipment as mentioned in section 2.03 J.1 then a Building Controller supporting RTC functionality shall be used in its place. AAC devices without RTC functionality will be permitted for use on terminal or unitary equipment such as VAV boxes, fancoils, heatpumps, univents and auxiliary monitoring and control.
4. Provide each Advanced Application Controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM under capacitor backup (lithium or rechargeable battery backup will not be permitted). Advanced Application Controllers must be fully programmable with a minimum of 200 lines of code available for custom programming. All programs shall be field-customized to meet the user's exact control strategy requirements. Advanced Application Controllers utilizing pre-packaged or canned programs shall not be acceptable. As an alternative, provide Building Controllers

for all central equipment in order to meet custom control strategy requirements.

5. Programming of Advanced Application Controllers shall utilize the same language and code as used by Building Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide a Building Controller to meet the specified functionality.
6. Local alarming and trending capabilities shall be provided for convenient troubleshooting and system diagnostics. Alarm limits and trend data information shall be user-definable for any point.
7. Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs. All new values and programs may then be restored to EEPROM via the programming tool.
8. Advanced Application Controllers that lose communication with master panels, and/or lose control due to a single sensor failure, are not acceptable.
9. At all Advanced Application Controllers include a hardwired, concealed and secured, RJ-11 or RJ-45 jack for use by the Portable Operators Workstation. The local operator, using the Portable Operators Workstation, shall plug into this jack, and shall perform all monitoring, control, and programming of sequences for any and all building-wide points and sequences while standing at any Advanced Application Controller.
10. At all Advanced Application Controllers, include the point database of the following minimum building-wide system data:
  - a. Building Primary Hot Water Return and Supply Temperatures
  - b. Building Primary Chilled Water Return and Supply Temperatures
  - c. Building Common Outside Air Temperature
  - d. Database for 10 other building-wide points, as field selected by OSU.

#### 2.04 ADVANCED APPLICATION CONTROLLERS (AAC) FOR "ASC" USE

- A. Application Specific Controllers are not permitted for use unless otherwise approved by The Ohio State University Medical Center. AAC devices shall be used for all intended ASC functionality. ASCs, by default, do not support the required BIBBs, or Read/Write capabilities as desired by The Ohio State University Medical Center.
- B. Each AAC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each AAC shall be a microprocessor-based, 32-bit, multi-tasking, real-time digital control processor.
- C. The use of these AACs is limited to the monitor and control of building HVAC equipment that are outside of any mechanical equipment room, or outside of any electrical equipment room. All equipment located within, or controlled from within, any mechanical equipment room or electrical equipment room shall use the peer-to-peer Building Controller.
- D. The electrical power source for these Advanced Application Controllers shall be from local circuit breaker with appropriate fused, class 2, 100VA power-limited output. The breaker shall be



dedicated to the Advanced Application Controllers, labeled accordingly, and locked-out from inadvertent casual shutoff.

E. Advanced Application Controllers:

1. Provide for control of each piece of building HVAC equipment, including, but not limited to, the following:
  - a. Variable Air Volume (VAV) terminal boxes
  - b. Constant Air Volume (CAV) terminal boxes
  - c. Dual Duct (DD) terminal boxes
  - d. Unit Conditioners
  - e. Heat Pumps
  - f. Unit Ventilators
  - g. Fan Coil Units
2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. All inputs and outputs shall be of the universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. Analog outputs shall be industry standard signals such as 24V floating control and 0-10 VDC allowing for interface to a variety of modulating actuators. Terminal equipment controllers or AACs utilizing proprietary control signals and actuators shall not be acceptable. As an alternative, provide Building Controllers or other AACs with industry standard outputs for control of all terminal equipment.
3. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor shall be 10K Type-3 thermistor based providing the following minimum performance requirements are met:
  - a. Accuracy:  $\pm 0.36^{\circ}\text{F}$
  - b. Operating Range:  $32^{\circ}$  to  $158^{\circ}\text{F}$
  - c. Set Point Adjustment Range:  $55^{\circ}$  to  $85^{\circ}\text{F}$  (adjustable)
  - d. Set Point Modes:
    - 1). Independent Heating
    - 2). Independent Cooling
    - 3). Night Setback Heating
    - 4). Night Setback Cooling
  - e. Calibration Adjustments: None required
  - f. Installation: Up to 500 ft. from Controller
  - g. Each room sensor shall also include the following auxiliary devices or options:
    - 1). Setpoint Adjustment Dial or equivalent buttons

- 2). Digital LED Temperature Indicator
  - 3). Override Switch or button
  - 4.). 2 % on board Humidity Sensor option
- h. The setpoint adjustment shall allow for modification of the temperature in a minimum of .5° F increments by the occupant. Setpoint adjustment may be locked out, overridden or limited as to time or temperature through software by an authorized operator at the central workstation, Building Controller, or via the portable operator's terminal.
  - i. The temperature indication shall be a digital display visible without removing the sensor cover.
  - j. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, Building Controller, or via the portable operator's terminal.
4. Each controller shall perform its primary control function independent of other DDC Controller LAN communications, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the Building Controller time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) values for all applications. All PID values and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings. Controllers that incorporate proportional and integral (PI) control algorithms only, without derivative (D) control algorithms, shall not be acceptable.
  5. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or capacitor backup. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPS's) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be fully customizable for specific applications (programming language shall be identical to the Building Controllers). In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of any applications or that are algorithm based will not be acceptable.
  6. Variable Air Volume (VAV) Box Controllers:
    - a. As a minimum, shall support the following types of applications for pressure independent terminal control:
      - 1). VAV, cooling only
      - 2). VAV, with hot water reheat
      - 3). VAV, with electric reheat
      - 4). VAV, fan-powered
      - 5). VAV, fan-powered, with hot water reheat

6). VAV, fan-powered, with electric reheat

- b. All VAV box control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory changes of any applications or that are algorithm based will not be acceptable
7. The VAV box controller shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 130°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
- a. The VAV controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 1 inWC and measurement accuracy of  $\pm 5\%$  throughout its range, insuring primary air flow conditions shall be controlled and maintained to within  $\pm 5\%$  of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.
  - b. The VAV box controller shall include provisions for manual and automatic reset of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Reset shall be accomplished by stroking the terminal unit damper actuator to 0%, full closed, position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the end user desires. Manual reset may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Reset of the transducer at the controller location shall not be necessary.
  - c. The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^\circ\text{F}$  (adj.) of setpoint at the room sensor location.
  - d. The VAV box controller performing space heating control shall incorporate a program allowing for modulation of a hot water reheat valve, or cycling up to three (3) stages of electric reheat, as required to satisfy space heating requirements. Each controller shall also incorporate a program that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.
8. Constant Air Volume (CAV) Box Controllers:

- a. As a minimum, shall support the following types of applications for pressure independent terminal control:
  - 1). CAV, cooling only
  - 2). CAV, with hot water reheat
  - 3). CAV, with electric reheat
- b. All CAV box control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes or those that are algorithm based will not be acceptable.
- c. The CAV box controller shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC, allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 130°F and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
- d. The CAV controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 1 inWC and measurement accuracy of  $\pm 5\%$  throughout its range, insuring primary air flow conditions shall be controlled and maintained to within  $\pm 5\%$  of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.
- e. The CAV box controller shall include provisions for manual and automatic reset of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Reset shall be accomplished by stroking the terminal unit damper actuator to 0%, full closed, position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the end user desires. Manual reset may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Reset of the transducer at the controller location shall not be necessary.
- f. The CAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^\circ\text{F}$  (adj) of setpoint at the room sensor location.
- g. Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve or cycling up to three (3) stages of electric reheat as required to satisfy space heating requirements. Each controller shall also incorporate a program that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space

cooling requirements. This program shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint. Control of the terminal unit damper to maintain cooling setpoint shall not be permitted. As an alternative, Building Controllers or other Advanced Application Controller for the associated air handling equipment shall also directly control all CAV terminal units in order to provide the specified reset capability

- h. Each controller performing space pressurization control shall incorporate programs allowing for pressurization via the following methods as a minimum:
  - 1). Fixed air volume setpoints of supply and exhaust terminal units
  - 2). Updating of air volume setpoints of supply and exhaust terminal units
- i. Each supply and associated exhaust terminal controller may be set at a fixed air volume setpoint which is within a percentage of each other or an actual CFM differential to meet space pressurization requirements. The controllers shall incorporate provisions for independent occupied and unoccupied mode setpoints and differentials, allowing for additional flexibility. Applications requiring updating of air volume setpoints depending on a variable volume of air leaving the space either through the exhaust terminal(s) or other exhaust ducts shall utilize supply terminal unit controllers incorporating programs to allow for "tracking" of space exhaust(s) to maintain the required air volume differential.
- j. Terminal unit tracking shall be accomplished via actual measurement of terminal unit air volumes as previously specified. Controllers which track within a range of CFM's versus actual CFM setpoints shall not be acceptable.
- k. Zeroing of the differential pressure transducer shall be accomplished as previously specified for VAV box controllers. However, the method of stroking the terminal unit damper to a 0% position shall not be permitted should the controlled space(s) require constant pressurization or 24-hour per day operation. Controllers performing under 24-hour per day operation requirements shall incorporate an 'Auto-zero' auxiliary device(s) which functions to automatically zero the transducer without changing the damper position. This shall be accomplished by temporarily disengaging the transducer from the air velocity sensor so that a 0 cfm air volume reading is forced. The control damper position remains unchanged, as originally controlled before the start of the 'Auto-zero' recalibration. This shall automatically occur on a once per 24-hour basis, thus ensuring system accuracy as previously specified. Provide auxiliary devices and programming as required to perform this function.
- l. Should a failure occur within the controller, the terminal unit damper shall automatically be positioned fully open or fully closed as previously defined by the operator. Controllers that revert to a pressure-dependent control mode during failure shall not be acceptable.

9. Dual-Duct (DD) Box Controllers:

- a. As a minimum, shall support the following types of applications for pressure independent terminal control:

- 1). DD - Constant Volume - Cold Duct & Hot Duct Air Velocity Sensors with

- optional auxiliary heat.
  - 2). DD - Constant Volume - Cold Duct & Outlet Air Velocity Sensors with optional auxiliary heat.
  - 3). DD - Variable Air Volume - Cold Duct & Hot Duct Air Velocity Sensors with optional auxiliary heat.
  - 4). DD - Variable Air Volume - Cold Duct & Outlet Air Velocity Sensors with optional auxiliary heat.
  - 5). DD -Variable Air Volume - Cold Duct & Hot Duct Air Velocity Sensors with changeover.
- b. All DD box control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes or those that are algorithm based will not be acceptable.
  - c. The DD box controller shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 130°F and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
  - d. The DD controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 1 inWC and measurement accuracy of  $\pm 5\%$  throughout its range, insuring primary air flow conditions shall be controlled and maintained to within  $\pm 5\%$  of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.
  - e. The DD box controller shall include provisions for manual and automatic reset of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Reset shall be accomplished by stroking the terminal unit damper actuator to 0%, full closed, position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the end user desires. Manual reset may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Reset of the transducer at the controller location shall not be necessary.
  - f. The DD box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^\circ\text{F}$  (adj) of setpoint at the room sensor location.
  - g. Each controller performing space heating control shall incorporate a program allowing for modulation of a hot water reheat valve or cycling up to two (2) stages

of electric reheat as required to satisfy space heating requirements.

- h. Provide two air velocity sensors and transducers to match the application. For VAV applications, provide separate minimum and maximum air volume setting for heating and cooling ducts. For CAV applications, provide separate air volume set points for occupied and unoccupied modes.
- i. Zeroing of the differential pressure transducer shall be accomplished as previously specified for VAV box controllers. However, the method of stroking the terminal unit damper to a 0% position shall not be permitted should the controlled space(s) require constant pressurization or 24-hour per day operation. Controllers performing under 24-hour per day operation requirements shall incorporate an 'Auto-zero' auxiliary device(s) which function to automatically zero the transducer without changing the damper position. This shall be accomplished by temporarily disengaging the transducer from the air velocity sensor so that a 0 cfm air volume reading is forced. The control damper position remains unchanged, as originally controlled before the start of the 'Auto-zero' recalibration. This shall automatically occur on a once per 24-hour basis, thus ensuring system accuracy as previously specified. Provide auxiliary devices and programming as required to perform this function.

10. Unit Conditioner Controllers:

- a. As a minimum, shall support the following types of applications for terminal control:
  - 1). Fan coil units
  - 2). Induction units
  - 3). Pressure dependent terminal boxes
- b. As a minimum, shall support the following types of fan coil units:
  - 1). Fan Coil, 2-pipe, heating or cooling
  - 2). Fan Coil, 4-pipe, heating or cooling
  - 3). Fan Coil, cooling, and electric heating
  - 4). Fan Coil, 2-stage cooling, and electric heating
  - 5). Fan Coil, 2-stage cooling, and hot water heating
- c. As a minimum, shall support the following types of Induction units:
  - 1). Induction Unit, 2-pipe
  - 2). Induction Unit, 4-pipe
- d. As a minimum, shall support the following types of pressure dependent terminal control:
  - 1). Heating, or cooling
  - 2). Hot water reheat
- e. All Unit Conditioner control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes

or those that are algorithm based will not be acceptable.

- f. The Unit Conditioner controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC, allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 130°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
- g. The Unit Conditioner controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^{\circ}\text{F}$  (adj) of setpoint at the room sensor location.
- h. The Unit Conditioner controller performing space temperature control shall incorporate a program allowing for modulation of a hot water reheat and chilled water valve, or cycling up to three (3) stages of electric reheat and chilled water valve, as required to satisfy space heating requirements. Each controller shall also incorporate a program that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements (if applicable). This program shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.

#### 11. Heat Pump Controllers:

- a. As a minimum, shall support the following types of applications for heat pump terminal control:
  - 1). Heat Pump, water source
  - 2). Heat Pump, air-to-air source
  - 3). Heat Pumps, with ventilation air
  - 4). Heat Pump, with auxiliary heat
- b. All Heat Pump control applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes or those that are algorithm based will not be acceptable.
- c. The Heat Pump controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC, allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 130°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).



- d. The Heat Pump controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^{\circ}\text{F}$  (adj) of setpoint at the room sensor location.
- e. The Heat Pump controller performing space temperature control shall permit full control of the Heatpump regardless of its configuration.

12. Unit Ventilator Controllers:

- a. As a minimum, shall support the following types of applications for heating only unit ventilator applications:
  - 1). Unit Ventilator, ASHRAE Cycle 1, 2 or 3
  - 2). Unit Ventilator, ASHRAE Cycle 1, 2 or 3 with auxiliary reheat
  - 3). Unit Ventilator, Nesbitt Cycle W
  - 4). Unit Ventilator, Nesbitt Cycle W with auxiliary reheat
- b. All Unit Ventilator controller applications shall be fully programmable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes or those that are algorithm based will not be acceptable.
- c. The Unit Ventilator controllers shall be powered from either a 115 or 230 VAC power source common to the unit ventilator. The controllers shall function normally under ambient conditions of 32° to 130°F and 10% to 95% (non-condensed). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly (unless mounted above ceilings or in a general area that is normally not accessible).
- d. The Unit Ventilator controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within  $\pm 1.5^{\circ}\text{F}$  (adj) of setpoint at the room sensor location.
- e. The Unit Ventilator controller shall also interface to averaging temperature sensor(s) located in the discharge or mixed air stream(s) as required by application. The sensor(s) must be 10-K type 3 thermistors, providing the following minimum performance requirements are met:
  - 1). Probe: Averaging type
  - 2). Accuracy:  $\pm .50^{\circ}\text{F}$
  - 3). Temperature Monitoring 0° to 180°F (-18° to 82°C)

2.05 PORTABLE OPERATOR'S TERMINAL (POT)

- A. Provide One (1) portable operator terminal (POT). The POT shall be a laptop configuration and plug directly into any control panel. Provide the BACnet BAS software as required to provide complete functionality for viewing and modifying of all data (including custom programs).
- B. Functionality of the portable operator's terminal connected at any controller:
  - 1. Access all controllers on the network.

2. Backup and/or restore DDC Controller databases for all system panels, not just the DDC Controller connected thereto.
  3. Display all point, selected point and alarm point summaries.
  4. Display trending and totalization information.
  5. Add, modify and/or delete any existing or new system point.
  6. Command, change setpoint, enable/disable any system point.
  7. Program and load custom control sequences as well as standard energy management programs.
- C. Connection of a POT to a distributed control processor shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.
- D. Portable operator terminal access to controller shall be password-controlled.
- E. Portable operator terminal minimum hardware and performance criteria shall be as referenced in Appendix A.2.

#### 2.06 PERSONAL COMPUTER OPERATOR WORKSTATION

- A. Personal computer operator workstations shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the controllers to facilitate greater fault tolerance and reliability. Personal computer operator workstation minimum hardware and performance criteria shall be as referenced in Appendix A.2.

#### 2.07 WORKSTATION OPERATOR INTERFACE SOFTWARE

- A. Basic Interface Description
1. Operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification and industry standard PC application software. The software shall provide, as a minimum, the following functionality:
    - a. Graphical viewing and control of environment
    - b. Scheduling and override of building operations
    - c. Collection and analysis of historical data
    - d. Definition and construction of dynamic and animated color graphic displays
    - e. Editing, programming, storage and downloading of controller databases
  2. Provide a graphical user interface, which shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

- a. Provide functionality such that all operations can also be performed using the keyboard as a backup interface device.
  - b. Provide additional capability that allows at least 10 special function keys to perform often-used operations.
3. The software shall provide multi-tasking operating system such that alarm notification occurs while user is running other applications such as Word or Excel; trend data uploads occur in the background while other applications are running. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows<sup>a</sup> or similar industry standard software that supports concurrent viewing and controlling of systems operations.
  - a. Provide functionality such that any of the following may be performed simultaneously, and in any combination, via user-sized windows: (Vector based graphics)
    - 1). Dynamic and animated color graphics and graphic control
    - 2). Alarm management coordinated with section 2.04.E.
    - 3). Time-of-day scheduling
    - 4). Trend data definition and presentation
    - 5). Graphic definition
    - 6). Graphic construction
  - b. If the software is unable to display several different types of displays at the same time, the BAS contractor shall provide at least two operator workstations.
4. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities. Privileges shall be customizable for each operator; the main menu shall reflect the privileges upon log on showing only the applications appropriate for the operator.
  - a. Customizable such that operators can monitor, command, or edit an application or group of points. An operator can be defined with privileges for access to a building, group or buildings, or areas (labs--point names with the designation "lab"), by application: the operator has monitor, command, and edit capability for time of day schedules and calendars (only) for the entire campus: or by function: the operator (i.e. security guard) has ability to view/monitor all areas of the campus and receive alarms, etc.
  - b. A minimum of 50 unique passwords, including user initials, shall be supported.
  - c. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used to log-on.
  - d. The system shall automatically generate a report of log-on/log-off time and system activity for each user.
  - e. User-definable, automatic log-off timers of from 5 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line as well as have the capability to generate a report of log-on, log-off time, parameters modified, and system activity for each user.

5. Software shall allow the operator to perform commands including, but not limited to, the following:
  - a. Start-up or shutdown selected equipment
  - b. Adjust setpoints
  - c. Add/modify/delete time programming
  - d. Enable/disable process execution
  - e. Lock/unlock alarm reporting for points
  - f. Enable/disable totalization for points
  - g. Enable/disable trending for points
  - h. Override PID loop setpoints
  - i. Enter temporary override schedules
  - j. Define holiday schedules
  - k. Change time/date
  - l. Automatic daylight savings time adjustments
  - m. Enter/modify analog alarm limits
  - n. Enter/modify analog warning limits
  - o. View limits
  - p. Enable/disable demand limiting for each meter
  - q. Enable/disable duty cycle for each load
  - r. Operator shall have ability to schedule reports to print at a pre-specified time and frequency and directed to displays, printers, disk or emails. The reports shall be capable of querying all BACnet devices for all BACnet data and shall be available in industry standard formats such as Acrobat, Microsoft Word, Microsoft Excel and Crystal Reports.

1) Summaries shall be provided for specific points, for a logical point group, for a user-selected group or groups or for the entire BACnet network without restriction due to the hardware configuration of the building automation system. At a minimum, the report function shall provide all required BACnet data for the previously identified BACnet objects in section 2.00 J.

#### B. Scheduling

1. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum:

- a. BACnet schedules
  - b. BACnet calendars
2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupancy and vacancy times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
3. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commandable points residing within the zone, unless custom programming is used to enable/disable the points. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone.
4. Monthly calendars, until the year 2020, shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

#### C. Collection and Analysis of Historical Data

1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. In addition, the BAS system shall automatically trend and archive all alarms and user activity (no exceptions).
2. Trend data report graphics shall be provided to allow the user to view all trended point data. The BAS system shall employ the use of Multiple Trend-Logs which may be customized to include up to 8 individual single trends in one viewable and printable format. Provide additional functionality to allow any trended data to be transferred easily to Microsoft Office, Excel ®. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.
3. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A maximum of 8 points may be viewed simultaneously on a single graph, with color selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.
  - a. Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or

scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.

- b. Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

#### D. Dynamic Color Graphic Displays

1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, room level terminal unit equipment shall be provided by the BAS contractor as indicated in the point I/O summary of this specification to optimize system performance analysis and speed alarm recognition. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.
2. Dynamic temperature values, humidity values, flow values, percent load, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.
3. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
4. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays.
  - a. The BAS contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.
  - b. The graphic package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:
    - 1) Define symbols
    - 2) Position and size symbols
    - 3) Define background screens
    - 4) Define connecting lines and curves
    - 5) Locate, orient and size descriptive text
    - 6) Define and display colors for all elements
    - 7) Establish correlation between symbols or text and associated system points or other displays
    - 8) Ability to import scanned images and CAD drawings in Autodesk®, DWG format.
  - c. Graphical displays can be created to represent any logical grouping of system

points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points that aids the operator in the analysis of the facility.

1) To accomplish this, the user shall be able to build graphic displays that include point data from multiple controllers.

5. Dynamic system status graphic of the site-specific architecture showing status of system hardware, including quantity and address of networks, field panels, terminal equipment controllers, and printers.
6. The BAS contractor shall employ the use of accurate floor plans as part of the overall graphics package. The floor plans shall illustrate the location of room sensors and equipment. In addition, the floor plans shall utilize a thermographic scheme to instantly alert the end user of hot and cold areas. The thermograph shall illustrate and automatically intensify the red and blue gradient fills for each area, as to indicate the severity of the overheating or overcooling problem.

E. System Configuration and Definition:

1. All temperature and equipment control strategies and energy management routines shall be definable and fully programmable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
  - a. Add/delete/modify stand-alone Building Controllers
  - b. Add/delete/modify stand-alone Advanced Application Controllers
  - c. Add/delete/modify operator workstations
  - d. Add/delete/modify Application Specific Controllers, if used
  - e. Add/delete/modify points of any type and all associated point parameters and tuning constants
  - f. Add/delete/modify alarm reporting definition for points
  - g. Add/delete/modify control loops
  - h. Add/delete/modify energy management applications
  - i. Add/delete/modify time and calendar-based programming
  - j. Add/delete/modify totalization for points
  - k. Add/delete/modify historical data trending for points
  - l. Add/delete/modify custom control processes
  - m. Add/delete/modify any and all graphic displays, symbols and cross-reference to point data

- n. Add/delete/modify dial-up telecommunication definition
  - o. Add/delete/modify all operator passwords
  - p. Add/delete/modify alarm messages
3. Definition of operator device characteristics, any controller's individual points, applications and control sequences shall be performed using instructive prompting software.
- a. All custom programming language must be line sequential, English text with a real time compiler. The operator shall be able to view all live data within the program with no exceptions. The use of secondary software or manual intervention shall not be required.
  - b. If programming must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.
  - c. Inputs and outputs for any process shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).
  - d. Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate controller. Similarly, changes made at any Controllers shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.
  - e. Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed. The help menus shall be readily accessible by selecting an icon or by pressing a function button on the keyboard.

## 2.08 WEB INTERFACE

### A. General

1. Furnish a Web-based access interface to the EMS system based on a client-server architecture, and allow for an unlimited number of simultaneous users (with Windows 2003 Professional server). An operator shall be able to access all the information in the system via a standard Web browser. The Web-page software shall not require a per user licensing fee or annual fees.
2. The Web interface shall be a separate software package and be installed as an "overlay" of the standard EMS software. The use of an embedded Web interface with a standard EMS software package will be prohibited (software packages must be separate).

### B. Browser Technology

1. Browser shall be a standard version of Internet Explorer 5 (or higher) or Netscape 6 (or higher). No special vendor-supplied software shall be needed on the thin-client



computers running the above browsers. All information shall be viewable, real-time and updated automatically without user interaction.

### C. Web Display

1. Web page graphics shown on the browser shall be replicas of the EMS displays. Operators shall need no additional training to understand the information presented on the Web pages when compared to what is shown on the EMS displays.
2. The Web interface shall automatically discover and display new devices that are connected to the BACnet network. In addition, all objects and associated properties will be automatically displayed without "mapping" or user intervention.
3. An operator, via the Web, shall have the ability to:
  - a. Navigate real-time through the system
  - b. Change all setpoints
  - c. View and acknowledge active alarms
  - d. Configure the system to email alarms to any other computer on the wide-area network (WAN).
  - e. Create and edit building schedules
  - f. Trend any point or value and display graphically or in table format
  - g. Manually override any input, output or value.
  - h. Display a summary of overridden points
  - i. Create new users or user groups, assign access privileges and edit existing user access privileges
  - j. Link graphics to .PDF files, AutoCAD files and Visio files to display sequence of operations and as-built documentation.
  - k. View and edit programs, and all input and output points

### D. Web Page Generation

1. All "EMS" displays shall be converted to HTML files automatically. The operator shall not be required to program in HTML.
2. All Web page graphics shall have dynamic graphic links with full animation of system components.
3. The Web site shall automatically generate a "network" tree, indicating all devices connected to the network.

### E. Password Security and Activity Log

1. Access via the Web browser shall utilize the same hierarchical security scheme as the EMS system. User shall be asked to log in once the browser makes connection to the

Web-page. Once the user logs in, any and all changes that are made shall be tracked by the EMS system. The user shall be able to change only those items that the user has authority to change.

#### F. Hardware

1. The PC requirements for the Web interface shall be industry standard "off the shelf" technology. Furthermore, the Web interface software and standard EMS software shall be installed on the same PC.

### 2.08 FIELD DEVICES

- A. Temperature Sensors: Each temperature sensor shall match the requirements of the associated temperature controller and shall be based upon 10-K Type-3 thermistors. Each sensor shall be designed for the appropriate application (i.e., duct, immersion, etc.) and be provided with all necessary installation accessories. Ranges shall be selected to the middle of the control range. Temperature sensors must have a minimum accuracy of +/- 0.5 deg F or .5 % of scale; whichever will provide the least error in measurement.
1. Electronic: A modulating solid state controller with built-in detector, P, PI, or PID controller, as required, with continuous voltage or current output. Each controller shall have individual setpoint, proportional band, start point, and span adjustments. Input voltage shall be 24 VAC or less. Each controller to be provided with night setback, summer/winter switchover or remote reset capabilities as required. Controllers shall be of matching type to the input detectors and output drives or sequencers.
  2. Thermostat guards shall be provided where specified, indicated on control diagrams, or indicated on floor plans. Guards shall be firmly attached to wall and thermostat cover shall be visible through the guard. All room sensors in public areas will have concealed setpoint adjustments.
  3. All room sensors in classroom, office, or common spaces will have exposed set point adjustments locked to provide adjustment between 68 degrees and 72 degrees only.
  4. Install thermostats and sensors at 4'-6" AFF to bottom unless otherwise noted on Architectural Drawings. Coordinate installation with the work of other trades before any rough-ins are made.
  5. Duct Sensors: DDC duct sensors shall match the requirements of the associated controller incorporating an electrical signal to insure exact and proportional relationship between the measured variable and the transmitted signal. Static pressure sensors shall be mounted in temperature control panels with connecting sensor lines in hard copper. Where a device is used for sensing of Mixed Air Temperature or Preheat applications and the duct area is in excess of 24 square feet the instrument shall incorporate a capillary averaging element with a minimum length of 96 inches or a suitable array of duct sensors wired as a single input. Averaging sensors shall be used on any duct application where duct area exceeds 24 square feet.
  6. Provide temperature sensors as required to meet the sequence of operation; in addition, provide temperature sensors in the following locations: return air, mixed air and discharge air sections if not required by the sequence of operation.
- B. Humidity Sensors: The relative humidity transmitter monitors and transmits changes in humidity, accurate to +/- 2 % RH. Operating range shall be 0 to 99% RH.

- C. Pressure Sensors: Duct static pressure analog sensors shall be high accuracy +/-1% of range suitable for the low pressures and selected for at least 50% over range Sensors shall have industry standard 4-20 mA output and zero end span adjustments.
- D. Control Dampers (Multiple Blade Dampers): Automatic dampers furnished by the BAS Contractor shall be single blade or multiple blades as applicable. All dampers are to be sized to the application by the manufacturer using methods similar to control valve sizing. Dampers are to be installed by the HVAC Contractor under the supervision of the Temperature Control Contractor. All dampers furnished by air handling unit manufacturers must meet the requirements listed in this section. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the HVAC Contractor. All damper frames are to be constructed of No. 13 gauge galvanized sheet metal and shall have flanges for duct mounting. Damper blades shall not exceed 6 inches width. All blades are to be airfoil type construction in ducts with air velocities above 1500 FPM and will be equal to Ruskin RCD 50 control dampers with blade and jamb seals. In applications with velocities less than 1500 FPM control dampers will be equal to Ruskin RCD46 control dampers. Blades are to be suitable for high velocity performance. All damper bearings are to be made of nylon. Bushings that turn in the bearings are to be oil impregnated sintered metal. Dampers hung with blades mounted vertically shall be provided with thrust bearings. Butyl rubber seals are to be installed along the top and bottom of the frame and along each blade edge. Independent, self-compensating, stainless steel end seals shall be installed to insure minimum leakage between blade ends and damper frame. Seals shall provide a tight closing low leakage damper. Damper sections shall not exceed 48" in length or 16 sq. ft. and shall have minimum of one operator per damper section. All dampers in modulating applications shall have opposed blades. Dampers in two position services shall have parallel blades. Where sequence requires, submittals shall include damper sizes and leakage characteristics. Leakage shall not exceed 1 % at 4" W.C. when tested per AMCA Standard 500.
1. Control dampers will be sized by the temperature control contractor to the inside of the duct or duct liner whichever is smaller. Sizing of dampers to duct size and the subsequent cutting back of insulation to make dampers fit is unacceptable.
  2. Control dampers used for outside air or exhaust air applications will be installed a minimum of 6" away from wall penetrations to allow for external mounting of their respective damper motors. Jack shafting in these applications will only be allowed to prevent having to mount motors in the outside airstream. When internal damper motor mounting is required the sheet metal contractor shall provide access panels at each motor location to allow for ease of service.
- E. Damper Operators: Operators shall be electronic, spring return, low voltage (24VAC), and shall be properly sized so as to stroke the damper smoothly and efficiently throughout its range. Actuator responses shall be linear in response to sensed load.
1. Electronic damper motors for terminal boxes will be provided by the temperature control contractor and shipped to the terminal box manufacturer for mounting. Mounting charges shall be the responsibility of the terminal box manufacturer.
  2. Damper operators on outside air intake/exhaust shall be spring return closed.
  3. VAV Terminal Boxes using internal or proprietary actuators are unacceptable.
- F. Automatic Control Valves: All valves shall be equipped with throttling plugs and removable composition discs and shall be manufactured by Siemens or Belimo. All valves are to be sized by the Control Contractor and shall submit pressure drop calculations and guarantee sufficient size

to meet the requirements of the equipment being served. Valve operators shall be of such design so as to provide adequate operating power for valve positioning.

1. Reheat valves controlled by AACs in VAV terminal applications shall utilize electronic actuation and shall fail normally closed (capacitor or spring driven failsafe). All reheat valves serving Laboratories and/or Vivariums (animal) rooms shall be electronic actuation and include spring return, to fail normally closed.
  2. Three-way Valves: Three-way valves are to be of the three port mixing arrangement, designed expressly for mixing of two inlets and providing a common outlet. The use of reverse piped diverting valves shall not be acceptable. The Temperature Control Contractor will assist the HVAC Contractor in providing guidance as to the correct method of piping of all three-way valves. It is the responsibility of the HVAC contractor to evaluate the contract drawings for proper verification.
  3. Butterfly valves for air handling unit coil control are unacceptable. If high GPM requirements dictate the valve size to be greater than 6", then Temperature Control contractor shall provide two control valves for the application, and the HVAC Contractor shall install the two control valves, for parallel and/or sequenced operation.
  4. For all fan systems with separate pre-heat and separate 2<sup>nd</sup> heating coil. The pre-heat coil shall fail normally open, shall include separate analog output AO point for control, and separate analog input AI point for low-limit pre-heat discharge control. The separate 2<sup>nd</sup> heating coil shall fail normally closed, shall include separate analog output AO point, and separate analog input AI point for low-limit heating control.
  5. For all fan systems with a single hot water coil, the coil shall fail normally open (i.e. AHUs, Fancoils Univents, UHs, CUHs, etc.)
  6. Pressure drop through modulating control valves shall not exceed 7 feet. Control valves for 2-position applications shall be line sized.
- G Air Volume Measurement: Provide Tek-Air or Ebtron air flow measuring system including microprocessor panel and air flow measuring sensor struts as required to measure outside air intake flow as denoted on the Drawings.
1. DDC air flow measuring system shall have a velocity range from 350 to 6000 ft./min. with duct measurement accuracy (including repeatability, zero offset, and temperature compensation) of plus or minus 0.5 percent.
  2. Pilot tube arrays and differential pressure arrays are not acceptable.
  3. The air flow measurement stations shall include a digital LCD display that illustrates the actual CFM, not FPM or other variables.
- H Smoke Detectors shall be provided and installed by the HVAC contractor. The electrical contractor will provide the necessary interlock wiring for life safety functions.
- I Air Static and Velocity Pressure Transmitter: The pressure transmitter shall be used for measuring duct static or velocity pressure in variable air volume fan systems.
- J Low Limit Detection Thermostat: Low limit detection thermostats equal to Siemens 134-1511 shall be of the vapor tension capillary type having a sensing element a minimum of 20 feet in length. These thermostats shall be of the manual reset type. The elements shall be complete with

necessary fittings to permit installation in the duct so as to sense the correct discharge temperatures. One low limit detection thermostat will be installed for every 24 square feet of protected area and arranged so as to stop their respective units and close the outside air dampers in the event discharge temperatures fall below 38 degrees F. The normally closed contact shall be wired to the fan circuit and the normally open contact (close on alarm) shall be wired to a DDC input. One common circuit is suitable for multiple thermostats on a single AHU coil area.

- K Electric Thermostats: Heavy-duty snap action type with key operators rated at 10 FLA at 120 RIAC contacts suitable for the intended service. Provide manual selector switches as required in the sequence of operation.
- L Fan and Pump Proof: Proof points for air handling unit fans, exhaust fans and pumps will be accomplished through the use of current sensing relays at the motor control center or motor starters. Current sensing relays shall be split-core design, for installation over any single power lead. Current sensing relays shall include field adjustable set screw for amperage setpoint adjustment, and shall include integral LED status light to locally indicate the 'on' and 'off' condition.
- M Variable Frequency Drives: The Variable Frequency Drives (VFDs) shall be supplied under this contract. The VFD shall be manufactured by Siemens or ABB and shall be sized and designed to appropriately control the motor loads. All VFDs shall incorporate a user friendly LCD display that clearly illustrates the drives parameters and current status (sometimes called advanced display). The BAS contractor shall coordinate with the electrical and HVAC contractor to ensure the proper implementation, location and wiring of all VFDs. The BAS contractor will be responsible for all low voltage wiring, while the electrical contractor will be responsible for all high voltage or line / load side wiring.

## 2.09 LABELING

- A. Provide labels for all field devices including sensors, transducers, thermostats, and relays. Exception: Room temperature and/or humidity sensors shall not be labeled.
- B. Labels shall be black laminated plastic with white letters and adhesive backing or screw fasteners. Labels shall be located adjacent to device and permanently affixed to device mounting surface. Labels for sensors in pipes may be secured using chain around the sensor well.
- C. Labels shall include system virtual/pseudo point name as well as English language name of device being controlled or specific condition being sensed.
- D. Identify all control wiring at each end with a wire tags or labels.

## **PART 3- EXECUTION**

### 3.01 SEQUENCE OF OPERATION

### 3.02 ON-SITE TESTING

- A. Field Test: When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. The installer shall complete all testing, calibrating, adjusting and final field tests. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. Upon completion of the work, notify the Owner, and/or Architect/Engineer that the system is ready for final tests and inspection.

- B. At the time of final inspection, this Contractor shall be represented by a person with the proper authority, who shall demonstrate, as directed by the Architect/Engineer, that his work fully complies with the purpose and intent of the Specifications and Drawings. Labor, services, instruments, and tools necessary for demonstrations and tests shall be provided by the Contractor.
- C. The Contractor shall test and adjust each instrument specialty and equipment furnished by him, prior to final acceptance. The Contractor shall demonstrate, for approval by the Architect/Engineer, subsystems operate as coordinated and properly functioning, integrated system.
- D. The Contractor shall furnish labor to provide adjustments and incidentals necessary to obtain the desired and intended results.
- E. The Contractor shall turn over a printed copy and electronic copy of the completed and debugged operating software to OSU at the conclusion of the two year warranty.

### 3.03 SERVICE AND GUARANTEE

- A. General Requirements: Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of two years after completion of successful performance test. Provide necessary material required for the work. Minimize impacts on facility operations when performing scheduled adjustments and non-scheduled work.
- B. Description of Work: The adjustment and repair of the system includes all computer equipment, software updates, transmission equipment and all sensors and control devices. Provide the manufacturer's required adjustments and all other work necessary.
- C. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. The OSU Medical Center shall be advised in writing of the name of the designated service representative, and of any changes in personnel.
- D. Systems Modifications: Provide any recommendations for system modification in writing to OSU. Do not make any system modifications, including operating parameters and control settings, without prior approval from OSU. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.
- E. Software: Provide all software updates and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with the system operators, and shall be incorporated into the operations and maintenance manuals, and software documentation.

### 3.04 TRAINING

- A. The Contractor shall provide competent and certified instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays as follows:
- B. Provide 40 hours of training for the OSU Medical Center operating personnel. Training shall include:

1. Explanation of drawings, operations and maintenance manuals
  2. Walk-thru of the job to locate control components
  3. Operator workstation and peripherals
  4. Building Controller, Advanced Application Controller operation/function
  5. Operator control functions including graphic generation and field panel programming
  6. Operation of portable operator's terminal
  7. Explanation of adjustment, calibration and replacement procedures
- C. Provide 8 hours of additional training quarterly for a period of one year from final completion of the project.
- D. Since OSU may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If OSU requires such training, it will be contracted at a later date. Provide description of available local and factory customer training.

---

END OF APPENDIX A



## The Ohio State University Medical Center

### EMERGENCY EYEWASH GUIDELINES

The Ohio State University Medical Center follows the American National Standards Institute (ANSI) standard Z358.1 for emergency eyewash equipment. The following are the guidelines for where to install emergency eyewash stations, what kind of eye wash equipment is required, and how they are to operate. Information on required testing and training is also listed below.

**Location of eye wash stations:** Emergency eyewash stations must be installed within 10 seconds walking time from the location of a hazard. The equipment must be installed on the same level as the hazard, and the path of travel from the hazard to the eyewash should be unobstructed. Eye wash stations are to be installed 33"-45" from the floor and 6" from the wall or nearest obstruction. The eyewash must be installed in a well-lit area.

**Eye wash equipment:** Emergency eyewash stations may be plumbed (unit is permanently connected to a source of potable water) or gravity-fed (unit contains its own flushing fluid and must be refilled or replaced after use). Eyewash stations should have a single handle to operate. Eyewash bottles may be located at workspaces that involve hazardous chemicals. The purpose of eyewash bottles is only to provide an eye flushing mechanism to use until the permanently installed eyewash has been reached; eyewash bottles may not be used as a substitute for plumbed or gravity-fed eyewash stations

**Eye wash operation:** Valves should activate in one second or less. The eyewash station must have a stay-open valve (leaving hands free). The eyewash should flow at the rate of 0.4 gallons per minute for 15 minutes for plumbed units at a rate of 30 PSI. Gravity-feed units should flow at a rate of 0.4 gallons per minute for 15 minutes.

**Eye wash signage:** A sign must be installed to identify the location of the eyewash.

**Testing:** The eyewash station will be checked weekly. The checks must be recorded in a log. The eyewash station must be operated for 3 minutes during testing. The water coming from the station should be tepid in temperature and clear in color. The pressure of the flow should be steady and without spurts.

**Maintenance:** All eye wash equipment shall be inspected annually. ANSI Z358.1 provides the requirements for proper function. Gravity-feed units shall be maintained according to the manufacturer's instructions. Facilities Services should be contacted for annual maintenance and repair issues.

**Training:** All employees who might be exposed to a chemical splash shall be trained in the use of the eye wash equipment located in their work area.



Product Miscellaneous

OSU		Product					
Standard Number	Standard Scheme	Item	Product Number	Manufacturer	Color	Description / Comment	Suggested Vender
		Miscellaneous					
SSC	Patient Room	Solid Surface counter	Eclipse	Corian	Eclipse	Solid surface counter top and sink	Ohio Valley Supply (800) 696-5608x51 John Kuna
TPD1	*	Compact double roll coreless tp dispenser	53771/01	Georgia-Pacific	smoke/grey	coreless bath tissue dispenser	Cottingham Paper Co.292-6444 Wayne Fulmer 1-800-870-5441
TPD2	*	Combo C-fold multifold dispenser	56650/01	Georgia-Pacific	grey/grey	c-fold, multi-fold towel dispenser	Cottingham Paper Co.292-6444 Wayne Fulmer 1-800-870-5441
TD1	*	NuRoll touchless towel dispenser	54087	Georgia-Pacific	smoke/grey	roll towel dispenser - large size	Cottingham Paper Co.292-6444 Wayne Fulmer 1-800-870-5441
TD2	*	Multifold towel dispenser	54701	Georgia-Pacific	white	multi-fold towel dispenser - space saver	
CT1	*	Changing Table	7818	Rubbermaid	OW Off White	Sturdy station changing table 37 7/8"L x 28 1/4"w x 19 1/2" H closed	Grainger 1-614-276-5231 Ned Kirpatrick
SCL	*	Sharps container large	8540-1H	Sharp star in room	biege	3-4 gallon wall enclosure	Tyco healthcare 1-800-833-3223 x2667 Tom Heitzenrater
SCM	*	Sharps container medium	8530-1H	Sharp star in room	biege	2-3 gallon wall enclosure	Tyco healthcare 1-800-833-3223 x2667 Tom Heitzenrater
SCS	*	Sharps container small	8516-1H	Sharp star in room	biege	5 quart wall enclosure	Tyco healthcare 1-800-833-3223 x2667 Tom Heitzenrater
GL	*	Glove dispenser	8550-LG	Sharp star in room	biege	glove dispenser and mounting bracket	Tyco healthcare 1-800-833-3223 x2667 Tom Heitzenrater
SCGD	*	Small Sharps Container / glove dispenser	8552-1H	Sharp star in room	biege	combined 5 quart wall enclosure w/ container, glove box	Tyco healthcare 1-800-833-3223 x2667 Tom Heitzenrater
WB1	*	trash can, 28 qt. - offices	2543	Rubbermaid	black or biege	trash can, 28 qt. - offices fire resistant	CIBI 442-5570
WB2	*	trash can, 28 qt, patient rooms	3559	Rubbermaid	black or biege	trash can, 28 qt, patient rooms	CIBI 442-5570
WB3	*	trash can, 18 gal, utility rooms	6145	Rubbermaid	black or biege	trash can, 18 gal, utility rooms	CIBI 442-5570
WB4	*	trash can, 8 gal, step on	6143	Rubbermaid	black or biege	trash can, 8 gal, step on	CIBI 442-5570

Product Miscellaneous

423 Indicates Discontinued  
Item

Product Miscellaneous

**OSU Medical Center  
Building Interior Schemes**

Buildings	Floors													
	T	G	1	2	3	4	5	6	7	8	9	10	11	12
Clinic	C	-	A	C	B	D	C	-	-	-	-	-	-	-
Davis	C	-	B	B	-	-	-	-	-	-	-	-	-	-
Doan	C	B	A	C	C	D	A	C	C	A	C	B	D	-
Dodd	C	-	B	B	A	D	-	-	-	-	-	-	-	-
James	-	D	C	B	C	C	B	-	A	B	D	C	C	A
Means	C	-	B	A	C	D	B	D	-	-	-	-	-	-
MRI	C	-	B	A	C	D	B	-	-	-	-	-	-	-
Neuropsych	C	-	B	D	A	C	C	-	-	-	-	-	-	-
Rhodes	C	B	A	C	C	D	A	C	C	A	C	B	D	-
Starling	B	A	C	C	B	D	-	-	-	-	-	-	-	-
Ross	-	-	F	F	-	F	F	-	-	-	-	-	-	-

Product Miscellaneous

	Scheme A	Scheme B	Scheme C	Scheme D
<b>Collins &amp; Aikman</b>				
	Calypso - Olive Grove	Rio - Paraguay	Odyssey - Callisto	Sail Away - Jib
	Infinity - Olive Grove		Voyager - Callisto	
<b>Interface</b>				
	Boucle Grid - Moonlight	Libra - Orbit		Earth - Plateau Wind - Plateau
<b>Mannington</b>				
	Business Casual - Chinos	Gametime II - Dimaggio	Business Casual - Deck Shoes	
		Business Casual - Deck Shoes	Business Class - E Ticket	
<b>Lee's</b>				
	Horsepower - Lime Rock		Artstone III - Surrealists	Invite T - Blue Willow

Product Miscellaneous

OSU			Product				
Standard Number	Standard Scheme	Item Flooring	Product Number	Manufacturer	Color	Description / Comment	Suggested Vendor
CPT1	A	Carpet	Calypso 23614	Collins & Aikman	Olive Grove	18"x18" vinyl back tile or 6' roll vinyl back, Mark 2 dryback condensed cushion	Legacy Commercial FLooring 614-476-1043 (Chris Rhinehart) Christopher.o.rhinehart@theenvironmental.com
CPT2	A	Carpet	Infinity 55013	Collins & Aikman	Olive Grove	18"x18" vinyl back tile or 6' roll vinyl back, Mark 2 dryback condensed cushion. Quick Ship.	Legacy Commercial FLooring 614-476-1043 (Chris Rhinehart)
CPT3	B	Carpet	Strategies	Mannington	Zenith	<del>18"x18" vinyl back tile or 6' roll vinyl back or quick ship 12' broadloom std action back, optional integra H vinyl 9' &amp; 12' available</del>	<del>Legacy Commercial FLooring 614-476-1043 (Chris Rhinehart) Christopher.o.rhinehart@theenvironmental.com</del>
CPT4	B	Carpet	Rio 38405	Collins & Aikman	Paraguay	18"x18" vinyl back tile or 6' roll vinyl back, Mark 2 dryback condensed cushion both quickship	Legacy Commercial FLooring 614-476-1043 (Chris Rhinehart) Christopher.o.rhinehart@theenvironmental.com
CPT5	C	Carpet	Composition	Mannington	Astronomer	<del>18"x18" vinyl back tile or 6' roll vinyl back or quick ship 12' broadloom std action back, optional integra H vinyl 9' &amp; 12' available</del>	<del>Legacy Commercial FLooring 614-476-1043 (Chris Rhinehart) Christopher.o.rhinehart@theenvironmental.com</del>
CPT7	D	Carpet	Calypso-23607	Collins & Aikman	Kaleidoscope	<del>18"x18" vinyl back tile or 6' roll vinyl back, Mark 2 dryback condensed cushion both quickship</del>	<del>Legacy Commercial FLooring 614-476-1043 (Chris Rhinehart) Christopher.o.rhinehart@theenvironmental.com</del>
CPT8	D	Carpet	Infinity-55024	Collins & Aikman	Kaleidoscope	<del>18"x18" vinyl back tile or 6' roll vinyl back or quick ship 12' broadloom std action back, optional integra H vinyl 9' &amp; 12' available</del>	<del>Legacy Commercial FLooring 614-476-1043 (Chris Rhinehart) Christopher.o.rhinehart@theenvironmental.com</del>
CPT10	E	Carpet	Composition	Mannington	Constellation	<del>18"x18" vinyl back tile or 6' roll vinyl back, Mark 2 dryback condensed cushion</del>	<del>Legacy Commercial FLooring 614-476-1043 (Chris Rhinehart) Christopher.o.rhinehart@theenvironmental.com</del>
CPT11	C	Carpet	Odyssey 14516	Collins & Aikman	Callisto	18"x18" vinyl back tile or 6' roll vinyl back, Mark 2 dryback condensed cushion	Legacy Commercial FLooring 614-476-1043 (Chris Rhinehart) Christopher.o.rhinehart@theenvironmental.com
CPT12	D	Carpet	Plateau-1666802500-4243	Interface	Wind		
CPT13	D	Carpet	Plateau -1666702500-4227	Interface	Earth		

Product Miscellaneous

CPT14	F	Carpet	Aria #50655	Shaw	Divine Modness 65750	
CPT15	F	Carpet	Bijoux #50660	Shaw	Lethally Chic 58706	
CPT16	B	Carpet	Gametime II	Mannington	DiMaggio	Quick Ship.

Product Miscellaneous

Number	Scheme	Flooring					
SV6	*	Sheet Vinyl Neutral Field	13401	Mannington GLS Fusion	Heather Beige	Inlaid sheet vinyl, 6" widths, heat or chemically welded seams	614-476-1043 (Chris Rhinehart)
SV8	*	Sheet Vinyl Neutral Field	13400	Mannington GLS Fusion	Amberjack	Inlaid sheet vinyl, 6" widths for neuropsych patient rms	614-476-1043 (Chris Rhinehart)
SSV5	*	Seamless Sheet Vinyl Accent	16007	Mannington Assurance	Putty	Homogeneous sheet vinyl flooring	614-476-1043 (Chris Rhinehart)
L1	*	Linoleum	dual, real	Forbo	color selection to be approved by facilities	2.5 mill, sheet 6'7" or 13x13, 20x20 tile	(Charles Love) charles.love@grainger.com
VCT6	*	Vinyl Composition Tile Field	51911	Armstrong Imperial	Classic White	12" x 12" tile 1/8" gauge	Resource Ohio (614)262-1140 (Brian Little)
VCT7	*	Vinyl Composition Tile Field	51927	Armstrong Imperial	Field Gray	12" x 12" tile 1/8" gauge	Resource Ohio (614)262-1140 (Brian Little)
VCT9	*	Vinyl Composition Tile Accent	51858	Armstrong Imperial	Sandrift White	12" x 12" tile 1/8" gauge	Resource Ohio (614)262-1140 (Brian Little)
VWF1	*	Vinyl Wood Flooring	W700	Amtico, Stratica	Cherry Brazilian Cherry -		Legacy Commercial FLooring 614-476-1043 (Chris
VWF2	*	Vinyl Wood Flooring	5631	Mannington Realities	Auburn		Legacy Commercial FLooring 614-476-1043 (Chris
VWFA3	*	Vinyl Wood Flooring Accent	W684	Amtico, Stratica	Maple	Accent for wayfinding insets (light color)	Legacy Commercial FLooring 614-476-1043 (Chris
VB1	*	Vinyl Base	63	VPI Premium	Smoke	6" @ corridor, 4" @ offices, or match existing	
VTS1	*	Vinyl Transition Strip	80	Johnsonite	Fawn		

\* Denotes that product can be used in all Schemes

123 Indicates Discontinued Item

Product Miscellaneous

OSU			Product			
Standard Number	Standard Scheme	Item Walls	Product Number	Manufacturer	Color	Description / Comment
VW20	A	Vinyl Wallcovering	M2-SLQ-08	Surface Materials Soliloquy	8	Type 2, 54" wide
VW21	A	Vinyl Wallcovering	TC-3501	York Contract Studio Source City Mapping		Type 2, 54" wide
VW11	B	Vinyl Wallcovering	1508-CT	MDC Wallcoverings	Lentex Catalon Driftwood	Type 2, 54" wide
VW12	B	Vinyl Wallcovering	L2-KY-21	Lanark	Ecru	Type 2, 54" wide
<del>VW22</del>	<del>C</del>	<del>Vinyl Wallcovering</del>	<del>395460-015</del>	<del>Maharam -Wave</del>	<del>Oyster</del>	<del>Type 2, 54" wide</del>
VW14	C	Vinyl Wallcovering	F421-33	Koroseal-Olympia	Harbour	Type 2, 54" wide
VW15	D	Vinyl Wallcovering	V221-30	Koroseal-Viewpoint	Oyster	Type 2, 54" wide
VW16	D	Vinyl Wallcovering	2527 RR	MDC Wallcoverings	Romeo-Talc II	Type 2, 54" wide
VW9	C	Vinyl Wallcovering	T2-NV-19	Tower	Parchment	Type 2, 54" wide
<del>VW10</del>	<del>E</del>	<del>Vinyl Wallcovering</del>	<del>T2-NV-18</del>	<del>Tower</del>	<del>Nava</del>	<del>Type 2, 54" wide</del>
VW17	*	Vinyl Wallcovering	LA21-91	Singer Vicratex Laviella	Appaloosa	Type 2, 54" wide / teflon coated
VW18	*	Vinyl Wallcovering	E11-167	Versa Origins Papyrus	Talc	Type 2, 54" wide / teflon coated
VW19	*	Vinyl Wallcovering	E11-169	Versa Origins Papyrus	Stonewash	Type 2, 54" wide / teflon coated
VW23	C	Vinyl Wallcovering	396990	Maharam - Terrain	1	Type 2, 54" wide
VWB4	*	Vinyl Wallcover Border	GMI62171-6	Design Tex	cloud nine	Height 8 5/8" for Procedure rooms
TP2	*	Toilet Partitions	D406	Corian	Eclipse, bisque	toilet partition, sink, built-in bedside cabinet top



Product Miscellaneous

Number	Scheme	Walls				
PT1	A, E	Wall Paint Accent	418-3	Pittsburgh Paints	Sourdough	On gypsum wall board - Accolade Interior Semi-gloss On gypsum wall board - Accolade Interior Semi-gloss Acrylic Latex Enamel
PT2	B	Wall Paint Accent	521-4	Pittsburgh Paints	Silver Dollar	On gypsum wall board - Accolade Interior Semi-gloss Acrylic Latex Enamel
PT3	C	Wall Paint Accent	422-4	Pittsburgh Paints	Puppy Paws	On gypsum wall board - Accolade Interior Semi-gloss Acrylic Latex Enamel
PT4	D	Wall Paint Accent	517-4	Pittsburgh Paints	Gray Stone	On gypsum wall board - Accolade Interior Semi-gloss Acrylic Latex Enamel
PT6	*	Wall Paint	217-1	Pittsburgh Paints	Crumb Cookie	On gypsum wall board - Accolade Interior Semi-gloss Acrylic Latex Enamel
PT7	*	Paint Door and Window F	521-5	Pittsburgh Paints	Eiffel Tower	On gypsum wall board - Accolade Interior Semi-gloss Oil-Based Enamel
PT13	*	Wall Paint Accent	214-2	Pittsburgh Paints	Sausalito	On gypsum wall board - Accolade Interior Semi-gloss Acrylic Latex Enamel - L & D
PT14	*	Wall Paint Accent	510-4	Pittsburgh Paints	Balsam	On gypsum wall board - Accolade Interior Semi-gloss Acrylic Latex Enamel - L & D
PT15	*	Wall Paint Accent	446-3	Pittsburgh Paints	Pale Violet	On gypsum wall board - Accolade Interior Semi-gloss Acrylic Latex Enamel - L & D
PT16	*	Wall Paint Accent	120-4	Pittsburgh Paints	Honey Bird	On gypsum wall board - Accolade Interior Semi-gloss Acrylic Latex Enamel - L & D
WPS1	*	Wall Protection Sys. Neutral	291	Koroguard	OSU Slate	H110 5 1/2" handrail w/ vinyl end cap C400 4" crash rail, G200 corner guard, .60 gauge sheet product Wall protection mounted from below hand rail to baseboard
WPS2	*	Wall Protect System		Koroguard	American Natural	
WPS3	*	Wall Protect System	wallcovering	Koroguard	K-11 Diaonas	.040 pvc sheet, .060 sheet (headwall)
WPS4	*	Wall Protect System	G200, B200	Koroguard	K-37 sea green	2" corner guard chair rail at top of wainscoting
WPS5	*	Wall Protect System	800, 1400, 150BN, 160BN , 405	IPC	buckeye gray	5 1/2" hand rail, 4" wall guard, 3" corner guard, 2" corner guard, door frame
WPS6	*	Wall Protect System	405W	IPC	0531 woodland finish	Wall protection mounted from below hand rail to baseboard
WPS7	*	Wall Protect System	405, 406, 160BN	IPC	haze	.040 pvc sheet , .060 sheet (headwall) 2' corner guard
WPS8	*	Wall Protect System	2500	IPC	seagrass	2" chair rail at top of wainscoting

123

Indicates Discontinued Item

Product Miscellaneous

Suggested Vender

Surface Materials  
1-800-231-3223 x125  
Contract Wallcovering  
1-800-227-2277  
MDC Wallcoverings, Inc,  
1-800-621-4006  
D.L. Couch  
1-800-433-0790

Maharam 1-800-645-3943

Singer 1-800-543-0412

Singer 1-800-543-0412  
MDC Wallcoverings, Inc,  
1-800-621-4006 x7475  
Surface Materials  
1-800-231-3223 x125

~~Surface Materials~~  
~~1-800-231-3223 x125~~

Singer 1-800-543-0412  
Contract Wallcovering  
1-800-227-2277  
Contract Wallcovering  
1-800-227-2277

Maharam 1-800-645-3943

Design Tex Ginger Mirtallo  
1-800-829-3839

Ohio Valley Supply  
1-800-696-5608x51 John Kuna

Product Miscellaneous

PPG Arch. Finishes ( Tim Taylor)  
PPG Arch. Finishes ( Tim Taylor)  
(614) 252-5800  
PPG Arch. Finishes ( Tim Taylor)  
(614) 252-5800  
PPG Arch. Finishes ( Tim Taylor)  
(614) 252-5800  
PPG Arch. Finishes ( Tim Taylor)  
(614) 252-5800  
PPG Arch. Finishes ( Tim Taylor)  
(614) 252-5800  
PPG Arch. Finishes ( Tim Taylor)  
(614) 252-5800  
PPG Arch. Finishes ( Tim Taylor)  
(614) 252-5800  
PPG Arch. Finishes ( Tim Taylor)  
(614) 252-5800

Singer 1-800-543-0412

Singer 1-800-543-0412

Singer 1-800-543-0412

Singer 1-800-543-0412  
Grainger 1-614-276-5231  
Ned Kirpatrick  
Grainger 1-614-276-5231  
Ned Kirpatrick  
Grainger 1-614-276-5231  
Ned Kirpatrick  
Grainger 1-614-276-5231  
Ned Kirpatrick

Product Miscellaneous

OSU		Product			
Standard Number	Standard Scheme	Item	Product Number	Manufacturer	Color
		Miscellaneous			
CC1	*	Cubical Curtains	8064-901	Design Tex	Orchard (Neutral)
CC2	*	Cubical Curtains	8708-101	Design Tex	Sand
WT1	*	Window Treatment	1" Mini	Hunter Douglas	Alabaster
WT2	*	Window Treatment	Vertical	Graber Ultra-Vue	color richmond ivory
		Window Treatment	roller shade	One-Touch Headrail	same color both sides
				Mechoshade	Light Grey - 0702; Light Grey 1010
ACT1	*	Ceiling Tile	769	Armstrong Cortega	
				Sqaure Lay-in Med Text	white
ACT2	*	Ceiling Tile	770	Armstrong Cortega	
				Sqaure Lay-in Med Text	white
ACT3	*	Ceiling Tile	703	Armstrong Cortega	
				Tegular Medium Texture	white
ACT4	*	Ceiling Tile	704	Armstrong Cortega	
				Tegular Medium Texture	white
ACT5	*	Ceiling Tile	2790	Armstrong Cortega	
				Second Look IV	white
ACT6	*	Ceiling Tile	2841	Armstrong Fine Fissured	white
ACT7	*	Ceiling Tile	755	Armstrong Fissured	white
				Armstrong Clean Room	
ACT8	*	Ceiling Tile	870	VL (non-perf)	white
				Armstrong Clean Room	
ACT9	*	Ceiling Tile	868	VL (non-perf)	white
ACT10	*	Ceiling Tile	756	Armstrong Fissured	white
CG1	*	Ceiling Grid			
CG2	*	Ceiling Grid			

Product Miscellaneous

Number	Scheme	Walls
Following ceiling tile matches exiting already in hospital		
reference *	Ceiling Tile	2310      USG Ceilings      white
reference *	Ceiling Tile	608      Armstrong Fine Fissured (white
reference *	Ceiling Tile	705      Armstrong Fissured      white
reference *	Ceiling Tile	1729      Armstrong Fine Fissured white Armstrong Clean Room
reference *	Ceiling Tile	1715/1716      Mylar      white
reference *	Ceiling Tile	2765      Armstrong Cortega Second Look      white
reference *	Ceiling Tile	2767      Armstrong Cortega Second Look      white
reference *	Ceiling Tile	2775      Armstrong Cortega Second Look      white
reference *	Ceiling Tile	76779      USG Ceilings Eclipse Clima Plus      white
reference *	Ceiling Tile	3352      Armstrong Optima - Open Plan      white
reference *	Ceiling Tile	1721      Armstrong Clean Room Mylar      white

Product Miscellaneous

\* Denotes that product can be used in all Schemes

OSU			Product		
Standard	Standard	Item	Product Number	Manufacturer	Color

Product Miscellaneous

Description / Comment	Suggested Vender
Babylon, 100% Avora FR polyester	Accent Draperies 488-0741 Brian Whiteside
Kildare	Accent Draperies 488-0741 Brian Whiteside
1" Mini Aluminum Blinds	Accent Draperies 488-0741 Brian Whiteside
Vertical Blind - Neutral 0700 Series Room Darkening (0% openness)1000 Series (2-3%)	Accent Draperies 488-0741 Brian Whiteside
Basic - 2 x4, University hospital only,15/16" white grid, square lay-in	Interior Supply 424-6611
Basic - 2x2 University Hospital only, 15/16" white grid, square lay-in	Interior Supply 424-6611
2x4Upgrade - Kitchen, SICU, 15/16" white grid, angled tegular	Interior Supply 424-6611
upgrade, 2x2, used throughout, 15/16" white grid, angled tegular	Interior Supply 424-6611
2x4 James/Solove only, 15/16" white grid, angled tegular	Interior Supply 424-6611
James/Solove, 9/16" white grid, angled tegular	Interior Supply 424-6611
used throughout, 2x4, fissured, square, lay- in, 15/16" white grid	Interior Supply 424-6611
replaces 864, 2x4, clean room VL, 15/16" white grid, square lay-in	Interior Supply 424-6611
2x2, clean room VL, 15/16" white grid, square lay-in	
2x2 throughout, fissured, lay-in, 15/16" white grid, square lay-in	Interior Supply 424-6611
15/16" white fire rated grid all medical ctr	
9/16" white fire rated grid - james only	

Product Miscellaneous

Replaces 345, 2x4, 5/8" Grid, Square Edge	Capitol Drywall (614) 276-6391
Fine Fissured Cermaguard replaces 602B, existing throughout	REW Material (614) 231-3440
2x2 James fissured, 15/16" white grid, angled tegular	Interior Supply 424-6611
replaces 779 fine fissured 2x2, square lay-in	Interior Supply 424-6611
2X4/2x2, clean room mylar, replaces 883, square lay-in white 15/16"	Interior Supply 424-6611
2x4 Rhodes & James, 15/16" white grid, angled tegular	Interior Supply 424-6611
2x4 Rhodes & James, 15/16" white grid, angled tegular	Interior Supply 424-6611
2x4 Doan, Rhodes Star/Lov, 9/16" grid angled tegular	Interior Supply 424-6611
replaces 76709 / 76907 2x2, 3/4" Shadowlined Paper Product Doan L&D, USG ceiling	Capitol Drywall (614) 276-6391 REW Material (614) 231-3440
2x2 white grid, square lay-in, 15/16", High NRC Tile	Interior Supply 424-6611
2x4 clean room mylar, 15/16" white square lay-in	Interior Supply 424-6611



Product Miscellaneous

Description / Comment

Suggested Vender

**MEDICAL CENTER SIGNAGE APPENDIX D**

2007 Edition, Published April 2007; Division Revision Date: February 28, 2013

**This section was removed and left blank on purpose.**

**Contact the OSUMC Signage Coordinator for Medical Center signage requirements:**

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

2013 Edition, Published February 28, 2013; Division Revision Date: February 28, 2013

*Please add a section for identification. Incorporate the following requirements in your standards. These requirements may be conveyed in a manner of your choice – no need to incorporate as shown.*

**PANEL DIRECTORIES**

1. All panel directories for new and renovation work will be generated using the Wexner Medical Center approved master Excel spreadsheet
2. Panelboards shall have new or updated paper directories printed from the master Excel spreadsheet inserted in the door
3. Any changes made to existing panels must be reflected on an updated directory that is to be printed and placed in the door as well as forwarded to Facilities Engineering in electronic format.
4. The Excel file used for printing is to be forwarded by email or saved on a form of removable storage media to Facilities Engineering for storage in the panel directory archive.
5. **PDF and scanned copies are unacceptable.**

<b>PANEL ID:</b>		<b>H5N1-1</b>	
<b>BUILDING:</b>	Heart Hospital		
<b>LOCATION:</b>	5th Floor Rm. 5039		
<b>PANEL RATING:</b>	3Ph 4W		
<b>MAIN SIZE/TYPE:</b>	225A MLO		
<b>VOLTAGE:</b>	120/208V		
<b>FED FROM:</b>	Busway Rm. 5077		
<b>MANUFACTURER/TYPE:</b>	Cutler Hammer		
<b>REVISION DATE:</b>	06/06/12		

BRANCH CIRCUIT DESCRIPTION	CIRCUIT NUMBER	BRANCH CIRCUIT DESCRIPTION
Recpt. Rm. 5038	1 *   2	Recpt. Rm. 5040
Recpt. Rm. 5038	3 *   4	Recpt. Rm. 5040
Recpt. Rm. 5038	5 *   6	Recpt. Rm. 5040
Recpt. Rm. 5038	7 *   8	Recpt. Rm. 5040
Recpt. Rm. 5036	9 *   10	Recpt. Rm. 5042
Recpt. Rm. 5036	11 *   12	Recpt. Rm. 5042
Recpt. Rm. 5036	13 *   14	Recpt. Rm. 5042
Recpt. Rm. 5036	15 *   16	Recpt. Rm. 5042
Recpt. Rm. 5034	17 *   18	Recpt. Rm. 5046
Recpt. Rm. 5034	19 *   20	Recpt. Rm. 5046
Recpt. Rm. 5034	21 *   22	Recpt. Rm. 5046
Recpt. Rm. 5034	23 *   24	Recpt. Rm. 5046
Recpt. Rm. 5032	25 *   26	Recpt. Rm. 5048
Recpt. Rm. 5032	27 *   28	Recpt. Rm. 5048
Recpt. Rm. 5032	29 *   30	Recpt. Rm. 5048
Recpt. Rm. 5032	31 *   32	Recpt. Rm. 5048
20A 208V rec. for I.S. rack in 5075M	33 *   34	Spare
20A 208V rec. for I.S. rack in 5075M	35 *   36	Spare
20A 208V rec. for I.S. rack in 5075M	37 *   38	Spare
20A 208V rec. for I.S. rack in 5075M	39 *   40	Spare
Spare	41 *   42	Spare

Example normal power panel

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

<b>PANEL ID:</b>	H5C5-1
<b>BUILDING:</b>	Heart Hospital
<b>LOCATION:</b>	5th Floor in Room H5077M
<b>PANEL RATING:</b>	225 Amp
<b>MAIN SIZE/TYPE:</b>	Main Lug
<b>VOLTAGE:</b>	120 / 208 VAC 3ø 4 Wire with Isolated Ground
<b>FED FROM:</b>	Bus Plug on Busway in Room H5077M / 200 Amp Switch with 200 Amp Fuses
<b>MANUFACTURER/TYPE:</b>	Cutler Hammer / BA Breakers
<b>REVISION DATE:</b>	03/27/08

BRANCH CIRCUIT DESCRIPTION	CIRCUIT NUMBER	BRANCH CIRCUIT DESCRIPTION
Roof Outside Recpt. 1GF + 2 duplex	1 *   2	Lts.Rms. 5200,5045,5049,5047
Elev. Machine Rm. 1GF & 1 duplex	3   * 4	Lts. Rms.5015,5009,5011,5079
Elev. Machine Rm. 2 duplex 1 GFI	5     * 6	Patient Rm.Lts.5054,5056,5058,5060
UH3 Elevator Machine Rm	7 *     8	Patient Rm. Lts.5046,5048,5050,5052
Elevator Louvers	9     * 10	Patient Rm.Lts. 5040,5042,5044
Rms. 5012,5010, E-7 Recpt.	11     * 12	Patient Rm.Lts. 5032,5034,5036,5038
Rms. 5008,5006,E-7 Recpt.	13 *     14	Patient Rm.Lts.5030,5028,5026,5024
Rms.5004,5002 E-7 Recpt.	15     * 16	Patient Rm.Lts.5022,5020,5018
Rms. 5046,5048 E-7 Recpt.	17     * 18	Patient Rm.Lts. 5016,5014,5012,5010
Rms. 5050,5052, E-7 Recpt.	19 *     20	Patient Rm.Lts.5008,5006,5004,5002
Rms. 5054,5056 E-7 Recpt.	21     * 22	Lts.Rm. 5075M,5275A,5215
Rms. 5058,5060 E-7 Recpt.	23     * 24	Rm.5075M 30 amp on rack
Door Operator X510C above ceiling	25 *     26	UPS in Room H5215 on Rack for Panel H5U1
Door Operator above ceiling Rm. 5204	27     * 28	UPS in Room H5215 on Rack for Panel H5U1
Spare	29     * 30	Spare
Rms. 5030,5032 E-7 Recpt.	31 *     32	Spare
Rms. 5028,5026 E-7 Recpt.	33     * 34	Spare
Rms. 5024,5022 E-7 Recpt.	35     * 36	Door Operator outside 5074 abv.clng.corr.X509C
Rms. 5020,5018 E-7 Recpt.	37 *     38	Spare
Rms. 5016,5014 E-7 Recpt.	39     * 40	Spare
Spare	41     * 42	Matrix Pnl Rm. 5215

Example emergency power panel (Critical Branch)

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

**WIRE COLOR CODE:**

WIRE COLOR CODE			
208/120 V		480/277 V	
CONDUCTOR	COLOR	CONDUCTOR	COLOR
<u>Phase A</u>	<u>Black</u>	<u>Phase A</u>	<u>Brown</u>
<u>Phase B</u>	<u>Red</u>	<u>Phase B</u>	<u>Purple</u>
<u>Phase C</u>	<u>Blue</u>	<u>Phase C</u>	<u>Yellow</u>
<u>Neutral</u>	<u>White</u>	<u>Neutral</u>	<u>Gray</u>
<u>Ground</u>	<u>Green</u>	<u>Ground</u>	<u>Green w/ yellow stripe</u>
<u>Iso Ground</u>	<u>Green w/orange stripe</u>		

**NOTES**

1. If existing phase colors differ from those outlined above, the existing color system must be maintained.
2. Provide wire color code at locations that wire may be or may become visible under any conditions.
3. Color coding shall be continuous on insulation for all conductors. For conductors larger than #6 where continuous color coding is not available, each conductor shall be marked with color tape at all connections and in all pull, junction and outlet boxes.
4. For 120 volt and 277 volt single phase circuits, Electrical Subcontractor shall provide additional identification to identify each neutral conductor with its associated phase conductor in all pull, junction and outlet boxes.

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

**RACEWAY COLOR CODE:**

RACEWAY COLOR CODE	
SYSTEM	COLOR
<u>Pwr Normal</u>	<u>Black</u>
<u>Pwr Emergency Equipment</u>	<u>Purple</u>
<u>Pwr Emergency Life-Safety</u>	<u>Brown</u>
<u>Pwr Emergency Critical</u>	<u>Yellow</u>
<u>Fire Alarm</u>	<u>Red</u>
<u>Nurse Call</u>	<u>Green</u>
<u>IS (TV, Data, FO)</u>	<u>Orange</u>
<u>Building Automation</u>	<u>White</u>
<u>UPS power</u>	<u>Blue</u>
<u>Clock</u>	<u>Pink</u>
<u>PA</u>	<u>none</u>

**NOTES**

1. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, plastic-sheet conduit markers, and extending 360° around conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker, matching adhesive plastic tape at each end of marker, or pretensioned snap-on. Except as otherwise indicated, provide lettering which indicates voltage of conductor(s) in conduit. Provide minimum 8" length for 2" and smaller conduit, 12" length for larger conduit.
2. Spacing of paint markings shall be a maximum of 10'-0" on centers for entire length of conduit. Painted conduit connectors and junction boxes will be an acceptable means of conduit identification, provided there is a painted connector/box a maximum of 10'-0" on center. Painting of box covers is NOT an acceptable method of identification.

**MEDIUM VOLTAGE RACEWAY IDENTIFICATION**

Where medium voltage raceways run within the interior of the building, including medium voltage raceways that are run in an inaccessible shaft, the raceway shall have "DANGER HIGH VOLTAGE"

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

painted in red paint with 2" tall letters, a maximum of 10'-0" on center. The raceway shall remain unpainted.

**CABLE TAGS**

1. Cable tags shall be brass identification tags with plastic tie wrap.

**COLOR CODED TAPE**

1. Colored tape shall be polyvinyl chloride, self-adhesive not less than 3 mils thick and 1 1/2" wide, suitable for use on 90°C conductors, UL listed and shall be furnished in colors as specified herein.

**NAMEPLATES:**

<u>SYSTEM</u>	<u>PLATE COLOR</u>	<u>LETTER COLOR</u>
<u>Normal</u>	<u>Black</u>	<u>White</u>
<u>Emergency Equipment</u>	<u>Red</u>	<u>White</u>
<u>Emergency Life Safety</u>	<u>Red</u>	<u>White</u>
<u>Emergency Critical</u>	<u>Red</u>	<u>White</u>

1. Material: Laminated plastic.
2. Fasteners: Stainless steel sheet metal screws. Small nameplate - each end. Large nameplate – each corner.
3. Lettering: Small nameplate – 1/8" minimum. Large nameplate – 1/4" minimum. All upper case letters.
4. Size: All nameplates for the same type of item shall be the same size. All sub-nameplates for an item shall be the same size.
5. Items that shall be provided a nameplate:

SMALL NAMEPLATE

- Disconnects
- Starters
- Combination Disconnect/Starters
- OPD's (except in branch panelboards)
- Motors
- Electrical Equipment (except large nameplate equipment)
- Systems Panels

LARGE NAMEPLATE

- Sub-Stations
- Switchgears
- Switchboards
- Panelboards
- Motor Control Centers
- Gen Sets
- Transfer Switches
- Transformers
- Elevator Panels
- Motorized Equipment
- UPS Units

6. Provide typed list of nameplates for approval.
7. Typical (not an all inclusive list) nameplates follow:

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

---

<u>BUILDING</u>	<u>BRANCH</u>	<u>EQUIPMENT</u>	<u>VOLTAGE</u>
<u>Central Plant – C</u>	<u>Critical – C</u>	<u>Distribution PnlBd – D</u>	<u>208/120 or 240/120 – L</u>
<u>CCCT - CC</u>	<u>Equipment – E</u>	<u>Gen Set – G</u>	<u>480/277 – H</u>
<u>Davis – DA</u>	<u>Life Safety – L</u>	<u>Motor Control Ctr – M</u>	
<u>Doan – D</u>	<u>Normal – N</u>	<u>Switchgear – S</u>	
<u>Dodd – DO</u>		<u>Transfer Switch – T</u>	
<u>Heart – H</u>		<u>Transformer – X</u>	
<u>James – J</u>		<u>Unit Sub-Station – U</u>	
<u>Neuroscience – N</u>			
<u>Rhodes – R</u>			

D3L5

208/120 BRANCH PANELBOARD

D: Building  
3: Floor  
L: Branch  
5: Sequential Number

D3LG

480/277 BRANCH PANELBOARD

D: Building  
3: Floor  
L: Branch  
G: Sequential Letter

D3SLL2

480/277 or 208/120 DISTRIBUTION EQUIPMENT

D: Building  
3: Floor  
S: Equipment  
L: Voltage  
L: Branch  
G: Sequential Number



**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

---

DISCONNECT SWITCH  
  
SUPPLY FAN J008  
  
FEED FROM J1DLN3 - 26 IN J013

Disconnects, Starters, Combination Disconnect/Starters

26: OPD Number

SUPPLY FAN J008  
  
FEED FROM J1DLN3 - 26 IN J013

Motors, Electrical Feed Equipment (except large nameplate equipment)

26: OPD Number

SUPPLY FAN J008  
  
AHU J006 IN J546M

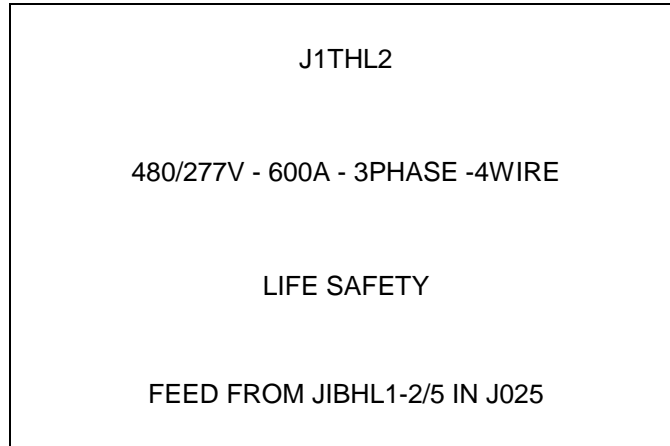
OPD's (except in branch panelboards)

J3SHC2  
  
480/277V - 600A - 3PHASE -4WIRE  
  
CRITICAL

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

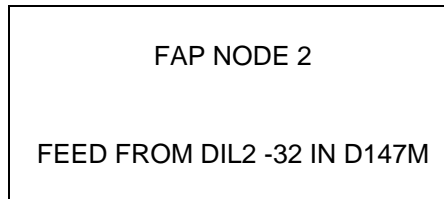
---

Sub-Station, Switchgears, Switchboards, Gen Sets

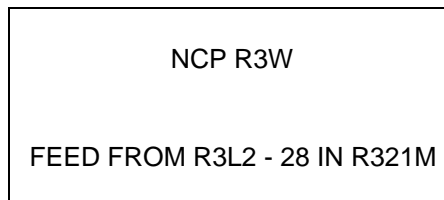


Switchgears, Switchboards, Panelboards, Systems Panels, Transfer Switches, Transformers, Motorized Equipment, UPS Units

2/5: 2: Section Number, 5: OPD Number



FIRE ALARM PANELS



NURSE CALL PANELS

N: Location, north  
E: Location, east  
S: Location, south  
W: Location, west

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

---

BAP R3-AHU-J006  
FEED FROM R4L2 - 22 IN R3561M

BUILDING AUTOMATION PANELS

**LABELS:**

Electrical and systems device cover plates shall be labeled.

1. Material: Vinyl
2. Color: Black lettering on white tape for normal. Red lettering on white tape for emergency equipment, emergency life safety, emergency critical.
3. Lettering: 12pt.
4. Size: ½" tape.

D3L2-14

ELECTRICAL DEVICES

14: OPD Number

D3-12-25, 26, 27, 28

SYSTEM DEVICES

12: Device sequential number  
25, 26, 27, 28: Jack number

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM LABELING AND IDENTIFICATION**

---

**ARC FLASH MARKINGS AND IDENTIFICATION:**

Flash Protection Boundaries and Incident Energy Exposures Labeling

1. Provide field labeling of electrical equipment that is likely to require examination, adjustment, servicing or maintenance while energized. Labeling shall be provided in accordance with the following codes and standards:
  - a. National Fire Protection Association
    - 1) NFPA 70 – National Electrical Code
    - 2) NFPA 70E - Standard for Electrical Safety Requirements for Employee Workplaces
  - b. IEEE Std 1584-2002 & IEEE Std 1584a-2004 - Guide for Performing Arc Flash Hazard Calculations
  - c. Underwriters Laboratories (UL) Factory Mutual (FM)
  - d. Occupational Safety and Health Administration (OSHA) – 1910.333
  - e. American National Standards Institute (ANSI)
  - f. American Society of Testing Materials (ASTM)
  - g. National Electrical Manufacturers Association (NEMA)
2. Flash protection boundaries and incident energy exposures field labeling shall warn persons of potential electric arc flash hazards and include as a minimum, specific to the equipment, the following information:
  - a. Warning of arc flash hazard
  - b. Requirement that only qualified personnel access equipment
  - c. Flash protection boundary limit
  - d. Incident energy exposure available
  - e. Date of installation
  - f. Statement that system changes occurring subsequent to the installation may affect the level of hazard involved and that additional electrical system review may be required to confirm level of hazard has not changed
3. Field labeling shall be applied to all electrical equipment including but not necessarily limited to:
  - a. Substation and switchboard assemblies
  - b. Panelboards
  - c. Disconnect switches
  - d. Controller equipment such as variable frequency/adjustable speed drives
  - e. Fuses and circuit breakers
  - f. Rotating equipment
  - g. Batteries
  - h. Generators
  - i. Automatic transfer switches
4. Field labeling shall be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment is performed. Field labeling shall conform to the requirements of ANSI Z535.4-1998, Product Safety Signs and Labels, provides guidelines for the design of safety signs

Example Arc Flash Labels

<b>!</b>		<b>WARNING</b>	
Arc Flash and Shock Hazard			
Appropriate PPE Required			
122 inch	Flash Hazard Boundary		
27.5	cal/cm <sup>2</sup> Flash Hazard at 18 inches		
Category 4	Cotton Underwear + FR Shirt & Pant + Multi Layer Flash Suit		
208 VAC	Shock Hazard when cover is removed		
00	Glove Class		
42 inch	Limited Approach (Fixed Circuit)		
0 inch	Restricted Approach		
0 inch	Prohibited Approach		
Bus: J3L Panel CDR5			

<b>!</b>		<b>DANGER</b>	
<b>NO PPE AVAILABLE</b>			
<b>ENERGIZED WORK PROHIBITED</b>			
579 inch	Flash Hazard Boundary		
356	cal/cm <sup>2</sup> Flash Hazard at 18 inches		
	Dangerous!!! No FR Category Found		
208 VAC	Shock Hazard when cover is removed		

**MEDICAL CENTER SPECIAL REQUIREMENTS APPENDIX E – ELECTRICAL SYSTEM  
LABELING AND IDENTIFICATION**

---

<b>00</b>	<b>Glove Class</b>
<b>42 inch</b>	<b>Limited Approach (Fixed Circuit)</b>
<b>0 inch</b>	<b>Restricted Approach</b>
<b>0 inch</b>	<b>Prohibited Approach</b>
<b>Bus: J3L Sub</b>	

## **Appendix G – Building Connection Basis of Design**

# Chilled Water Plants

Building Connection Basis of Design,  
Operations and Maintenance

April 30, 2013  
Revision 2



**Facilities Operations  
and Development**

---



**Table of Contents**

1.01 INTRODUCTION..... 3

1.02 ABBREVIATIONS ..... 3

1.03 DEFINITIONS..... 4

1.04 CHILLED WATER PLANTS - OVERVIEW ..... 7

2.01 BUILDING SYSTEM REQUIREMENTS ..... 8

    A. Building Interfaces and Interconnections..... 8

        1. Direct Connect to the Plant Chilled Water (Figure 2)..... 8

        2. Indirect connect via Plate and Frame Heat Exchanger (Figure 3)..... 11

    B. Common Requirements (for all systems) ..... 15

        1. Secondary Chilled Water Pumps ..... 15

        2. Pump Head Pressure Requirements ..... 16

        3. Secondary Loop and Tertiary Loop Chilled Water Pump Selections ..... 17

        4. Emergency Isolation Valves..... 17

        5. Chilled Water Cooling Coils ..... 17

        6. Air Removal..... 17

        7. Piping and System Components..... 18

        8. Chilled Water Metering..... 21

        9. Risk Management Issues ..... 21

        10. Building Interfaces..... 22

        11. Building & Plant Chilled Water Supply and Return Temperature Optimization ..... 22

        12. South Campus Standby Chilled Water Signaling..... 23

    C. Test, Adjust, and Balance (TAB)..... 24

        1. TAB Contractor’s Requirements ..... 24

        2. Balancing Devices..... 24

        3. Required TAB Preparation ..... 24

        4. Reporting ..... 25

    D. Commissioning ..... 25

    E. Responsibility Matrix ..... 26

        Chiller Plant Building Map ..... 27

        Design Sketches Figures 2 and 3..... 28

        Equipment Responsibility Matrix Figure 4..... 30

## 1.01 INTRODUCTION

- A. This guideline summarizes the technical requirements, and informs planners, designers and building operators of the buildings served by centralized chiller plants on the basis of design of the buildings' interconnection with the central chiller plant systems. These guidelines impact the design for all buildings to be connected and served by these central chiller plants.
- B. The plant systems, distribution systems, and building chilled water systems function as a system. The system components are interactive, and each section of the system, even if designed and operated by different entities, must function interactively. Most important, the connected buildings must maintain system performance so the central plant is not degraded by a single failed building system.
- C. Energy efficiency is a high priority. The efficiency of the plant is impacted by the chilled water supply and return temperatures, hours of operation and seasonal requirements. The building designer must consider the impact of the building design on demands on the central chilled water plant, and take all reasonable and necessary steps to design an efficient system, minimizing the demands on the plant.
- D. See Figure 1 at the end of this document for plans of the campus central chilled water systems.

## 1.02 ABBREVIATIONS

A/E	Architect / Engineer
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
BAS	Building Automation System
BOD	Basis of Design
CHW	Chilled Water
DSAW	Double Submerged Arc Welded
DCS	Digital Control System
°F	Fahrenheit
FOD	Facilities Operations and Development
FPS	Feet per Second
GPM	Gallons per Minute
HVAC	Heating Ventilating and Air Conditioning
KSI	Kilo-Pound per Square Inch
MC	Wexner Medical Center
OPR	Owner's Project Requirements
OSU	The Ohio State University

NRD	North Residential District
PID	Proportional Integral Derivative
P&ID	Process / Piping and Instrumentation Diagram
PSIG	Pressure, Pounds per Square Inch Gauge
RTD	Resistance Temperature Detector
$\Delta T$	Temperature Differential
VFD	Variable Frequency Drive

### 1.03 DEFINITIONS

- A. BACnet – Building Automation Control network. A control network developed by ASHRAE primarily for interoperability between commercial automation systems.
- B. Basis of Design – The BoD is a document that records the general expectations, performance criteria and special requirements as they relate to the project technical design elements. The BoD includes both narrative descriptions and lists of individual items that support the design process documenting the primary thought processes and assumptions behind design decisions that were made to meet the OPR.
- C. Building Chilled Water Pumps, Secondary - Pumps installed to circulate chilled water from the plant and to the building.
- D. Building Chilled Water Pumps, Tertiary - Pumps to circulate chilled water through the building. These pumps are only required when a plate & frame isolation is employed.
- E. Building Operator: The person or group responsible for maintenance building cooling system and responding to alarms. Building Automation Shop (BAS) or Wexner Medical Center Building Engineer.
- F. Chilled Water - Needed to cool and dehumidify supply air of the Ohio State Campus and Wexner Medical Center buildings.
- G. Chilled Water Delta-T - The change from entering to leaving chilled water temperature through a chiller, cooling coil, or building service entrance.
- H. Chiller – A machine to remove heat from a liquid (chilled water) via a vapor-compression refrigeration cycle.
- I. Cooling Tower – Device that uses evaporation to reduce water temperature, and is the primary means of rejecting heat from condenser water. Cooling tower effectiveness is heavily dependent upon significant quantities of drier air. Towers are sized based on approach to outside air wet bulb temperature. During colder

weather, may be used to generate building chilled water directly, without the use of chillers.

- J. Cooling Tower Plume – Visual plume often seen during cold weather operation. Plume is moist air, often perceived to be, but not necessarily contaminated. Depending upon wind and air temperatures, the plume may have to be controlled. The plume or air currents from the tower outlet may adversely effect aircraft operation. The cooling tower removes particulates from the air and requires a sand filter to remove the particulates from the circulating water.
- K. Commissioning – A systematic quality assurance process to ensure that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent. Commissioning starts with clarification of the Program of Requirements, and continues through the warranty phase.
- L. Ethernet – Is a family of frame-based computer networking technologies for local area networks (LANs).
- M. Expansion Tank – Required in a closed loop water system to compensate for the expansion or contraction of the fluid with varying operating temperatures. For a chilled water system, a properly sized expansion tank will accommodate the expansion of the system fluid during plant shutdown, or reduced cooling (warmer water) cycle without the system exceeding the upper pressure limits of the system.
- N. Firm Capacity – Plant chiller capacity with one of the largest chillers out of service.
- O. Industrial Grade – Higher quality and more robust equipment designed and manufactured to withstand more demanding duty, closer tolerances and/or harsh environments.
- P. Isolation Valve – A valve to isolate equipment from the remainder of the system for maintenance or replacement. This may be a manual or automatic, and normally open (NO) or normally closed (NC).
- Q. Magnetic Flow Meter (Magmeter) – A high quality, high accuracy electronic flow meter that measures flow by electromagnetic induction.
- R. Modbus – An “open” protocol developed by Modicon in the 1970s. This communication protocol is commonly used in electrical and industrial market segments. This protocol uses master / slave or client / server relationships and ASCII or RTU.

- S. Modulate – To gradually open or close a control device in response to a control signal to vary fluid or air flows.
- T. Owner’s Project Requirements – A document that outlines measurable objectives for use during the project design, construction and operation.
- U. Plate and Frame Heat Exchanger – A static device that uses metal plates to separate two fluid systems, with heat transfer between the fluids in the two systems. May be used for tower free cooling and/or building service entrance applications. A plate & frame exchanger is required in tall buildings, for the isolation of contaminated systems or for systems with cooling coils that are unable to achieve the design 16 degree delta T.
- V. Programmable Logic Controller (PLC) – An industrial grade programmable control device that is of higher quality, faster, more reliable, and more capable of programming variations.
- W. Primary Chilled Water Loop – The chilled water supply and return distribution piping and equipment in the Chiller Plant, including the supply and return distribution piping to each building service entrance.
- X. Secondary Chilled Water Loop – The chilled water distribution system that draws chilled water from the primary chilled water loop, circulates it to the building service entrance, and returns the chilled water to the primary chilled water loop. A secondary chilled water loop can provide chilled water directly to building HVAC equipment, or it can be separated from the building equipment by a plate and frame heat exchanger
- Y. Standby Generation – Equipment to provide electrical power to ‘mission critical’ plant equipment during a power outage.
- Z. Static Pressure – The fluid pressure in the system, influenced by the height of the water column above that point in the system. Each foot of elevation change above that point will require a 0.43 psi increase in pressure to maintain water in the pipe above. The static pressure required at the top of the highest building or at the plate and frame heat exchanger should be 10 psi over the pressure required to keep the system full at that elevation. Static Pressure is typically defined in feet of head, not psi. 1 foot of head equals 0.43 psi; 1 psi equals 2.33 feet of head.
- AA. Tertiary Chilled Water Loop – The chilled water distribution system on the building side of a plate and frame heat exchanger. This pumping is required with building plate and frame heat exchangers.

- BB. Three-Way Control Valve – Automatic control valve that modulates between open and closed positions with bypass from supply to return. This valve is ported with normally open, normally closed and common ports. Commercial control valves typically have the normally open control valve as the “bottom” port.
- CC. Total Capacity – Capacity available with all chillers operating.
- DD. Two-Way Control Valve – Automatic control valve that modulates between open and closed positions with no bypass from supply to return.
- EE. Ultrasonic Flow Meter – A device that measures flow by sensing its Doppler effect on an ultrasonic signal transmitted into the fluid.
- FF. Variable Frequency / Variable Speed Drives – A technology to control the speed of an alternating current (AC) electric motor by varying the frequency of the electrical power supplied to the motor. A variable speed drive also functions as a starter, or soft start device.
- GG. Water Treatment – Chemical additives for to clean, treat, and to prevent corrosion in the chilled water piping. Chemical treatment is also used in tower water piping to prevent corrosion and microbiological growth. Blowdown is draining part of the system water to reduce dissolved solids in the system and prevent scale formation. Makeup is city water added to the system to replace water lost through evaporation or blowdown.
- 1.04 CHILLED WATER PLANTS - OVERVIEW
- A. The **McCracken Chilled Water Plant** (MCWP) has 15,550-tons of total capacity. This plant mainly serves academic buildings located on the core of Main Campus. The plant has seven R-134a chillers sized at 2,000 tons and two 775-ton R-123 chillers. One chiller is in reserve to satisfy cooling requirements (N+1). 736 feet elevation is the reference level for the MCWP system pressure.
- B. The **South Campus Central Chiller Plant** (SCCCP) has 20,000 ton plant of total capacity (as of mid 2014). The plant serves the Wexner Medical Center and the 12th Avenue research corridor facilities. The plant has chillers sized at 2,500 tons.. Expansion plans are to maintain one chiller in reserve to satisfy cooling requirements (N+1). At full build out, the plant will have 27,500 tons firm capacity, and 30,000 tons of total capacity. Of the 27,500 ton firm capacity, 17,500 tons is designated for Wexner Medical Center facilities, and 10,000 tons for the 12th Avenue research corridor facilities. The initial phase of the SCCCPC included standby generator capacity to operate 5,000 tons of chilled water production dedicated to the Wexner Medical Center during a utility power outage. 719 feet elevation is the reference level for SCCCPC system pressure.

- C. The **East Regional Chilled Water Plant** (ERCWP) will initially be a 5,000 ton total plant capacity, and ultimately built to 15,000 tons. The plant will serve the majority of the Academic Core North buildings and portions of the North Housing District. The plant will have chillers sized at 2,500 tons, initially required to produce a firm capacity of 2500 tons. One chiller is in reserve to satisfy cooling requirements (N+1). At full build out, the plant will have 12,500 tons firm capacity, and 15,000 tons of total capacity. Of the 12,500 ton firm capacity, 3,000 tons is designated for the North Housing District. 736 feet elevation is the reference level for the ERCWP system pressure.
- D. Each central chiller plant operates continuously on a year 24/7/365 basis, providing 42°F chilled water supply. In the future, plants may be cross connected to optimize winter operations or to share reserve capacity.
- E. In compliance with University sustainability goals, the plant chilled water system and associated equipment is operated to optimize energy savings.
- F. The Architect-Engineer of any new or renovated building system to be connected to and served by central chiller plants shall coordinate with Facilities Operations and Development and with Utilities for the technical requirements of the building systems, as they relate to chilled water needs and use.
  - 1. The project location, building height, existing building HVAC equipment, and building chilled water requirements will determine whether or not the project will be directly or indirectly connected to the primary chilled water loop.
  - 2. The new building systems must be designed with cooling coils and other HVAC devices compatible with the intended chilled water supply and return water temperatures to and from the central chiller plant.
  - 3. The building shall not be designed to require extraordinary or excessive cooling requirements that will force excessive operation, or override normal operation of the plant. The plant normal operating guidelines are stated in this document.

## 2.01 BUILDING SYSTEM REQUIREMENTS

- A. Building Interfaces and Interconnections (either direct connect or indirect with plate and frame, described in the following two sections).
  - 1. Direct Connect to the Plant Chilled Water (Figure 2)
    - a. The building chilled water system will direct connect to the distribution piping and share chilled water with the central plant.

- b. The entering campus supply chilled water design conditions will be 42°F at the building with a 16°F delta-T for the building chilled water system.
- c. The chilled water system static pressure at the Plants shall be set to 80 PSIG (185 feet of water). All facilities connected to this system shall assume this maximum static pressure value with a direct connection. When the building system exceeds this static pressure value, an indirect connection is required. See the “Indirect Connect via Plate and Frame Heat Exchanger” section.
- d. Building HVAC components shall be rated for 150 psig and piping installations shall comply with ASME B31.1.
- e. The expansion and contraction of the volume of water in the building will be accounted for at the central plants. Expansion tanks shall not be permitted for building systems that are directly connected to the central plant chilled water.
- f. Existing buildings with aging equipment, piping, and HVAC systems designed for less than a 16°F delta T shall not be direct connected to the central chiller plants’ chilled water system
- g. As a shared piping system, all direct connect building chilled water systems shall have makeup water supplied by the central plant makeup water system only. For initial fill requirements see Section 2.01 B. 7. g. and Commissioning Section 2.01 D.
- h. The physical interconnection of the building systems with the plant chilled water system will require special attention to cleaning, pressure testing, filling, and flushing (see section B.7.g. below).
- i. Direct Connect Secondary Chilled Water Pump Control:
  - 1) Each building will have one set of variable speed secondary chilled water pumps.
  - 2) The secondary chilled water pump speed will vary to provide the required chilled water differential pressure to provide adequate building flows.
- j. Direct Connect Process Load Sequence
  - 1) When connecting a process load that requires a constant flow, there must be separate pumps on the supply side after the bypass



section. The bypass section must also have a 3-way valve that is common to the return from the process and normally open to the plant return.

- 2) When a process load has a variable flow rate, it is treated the same configuration that is used for the constant flow system.
  - 3) The process loops that have been connected to central distributed chilled water run between 58-60°F supply water to the process to minimize the possibility of condensation on the equipment it is serving.
  - 4) One type of process load control scheme is to modulate a 3-way valve to maintain the process water supply temperature.
- k. Direct connect Sequence of Operation
- 1) When the cooling enable flag is turned on based on the outside air temperature exceeding the enable temperature, the automatic isolation valves shall be commanded open.
  - 2) Upon proof that both automatic isolation valves opened, the lead pump (secondary) shall be commanded on, and the PID control loop shall modulate the VFD pump control and the 2-way valve to maintain the differential pressure set point of the furthest coil on the system.
  - 3) 2-way valves on coil chilled water flow will be modulated to meet air handler discharge temperature.
  - 4) When the cooling enable flag is reset, when the outside air temperature goes 2° below the enable temperature (adj), the pump shall be commanded off.
  - 5) Upon proof that the pump went off, all automatic isolation valves shall be closed.
  - 6) There shall be timers to track the run hours of each pump.
  - 7) Upon failure of the differential pressure sensor or signal, the control point shall switch to the return water temperature sensor, and maintain 58°F return. There shall also be a minimum speed on the flow that is 10% of total balanced flow set point (adj.). An alarm flag to the Building Operator shall also be set.
  - 8) Alarms shall be annunciated for the following conditions:

- a) VFD Fault.
  - b) Low Flow Fault - System running with no flow.
  - c) Low Delta T Fault while running, 5 minute on delay timer.
  - d) High Delta T Fault while running, 5 minute on delay timer.
  - e) Automated isolation valve failed to open/close.
2. Indirect connect via Plate and Frame Heat Exchanger (Figure 3)
- a. Use a plate and frame heat exchanger to pressure isolate the tertiary chilled water system from the secondary chilled water when:
    - 1) the buildings' chilled water system pressure exceeds 80 PSIG, or
    - 2) the buildings' HVAC systems are designed with less than a 16°F delta T, or
    - 3) there are aged and deteriorating piping systems that could cause piping leaks or chilled water contamination.
  - b. Plate and frame heat exchangers
    - 1) Selected to maximize the plant chilled water system temperature differentials, considering losses on both the supply and return water side. Therefore, the flow rates on the plant and building side must closely match for heat transfer and system performance. The supply water temperature on the building side of the plate and frame will be 2°F to 3°F warmer than the central plant supply chilled water temperature (to account for heat exchanger efficiency losses). The entering campus supply chilled water design conditions will be 42°F, and the campus return chilled water design conditions at 58°F therefore the buildings should expect 44 to 45°F design entering water and 60 to 61°F design leaving water.
    - 2) The plate and frame heat exchanger shall be ASME Stamped.
    - 3) A minimum of two plate and frame heat exchangers will be provided for each building.
    - 4) Two units will permit cleaning and maintenance operations while operating the building under partial loads.

- 5) Each unit shall be equally sized, and sized to support 60% or more of the total building load.
  - 6) Both units will remain in service (with the exception of maintenance or control sequence operation) at all times to maximize heat transfer surfaces and minimize water temperature differences between plant and building side chilled water.
- c. The expansion and contraction of the volume of water in the building side of the plate and frame will require expansion capabilities. All plant side expansion shall be accommodated at the central plant.
  - d. Building Makeup Water – (for indirect connect only)
    - 1) A fill connection with appropriate back-flow prevention is required for facilities to be connected to the system.
    - 2) Make-up water meter is required and provided with a flow meter that is monitored and alarmed by the building chilled water system control system.
  - e. The physical interconnection of the building systems with the plant chilled water system will require special attention to cleaning, pressure testing, filling, and flushing (see section 2.01 B.7.g below).
  - f. Indirect Connect Secondary Chilled Water Pump Control
    - 1) Each building will have one set of variable speed secondary chilled water pumps
    - 2) The secondary chilled water pumps will control secondary flow to track tertiary flow plus 5% (adjustable).
  - g. Indirect Connect Tertiary Chilled Water Pump Control
    - 1) Each building will have one set of variable speed tertiary chilled water pumps.
    - 2) The tertiary chilled water pump speed will vary to provide the required chilled water differential pressure to provide adequate building flows.
  - h. Indirect Connection Sequence of Operation (New Building Systems):

- 1) When the cooling enable flag is turned on based on the outside air temperature exceeding the enable temperature, the automatic isolation valves shall be commanded open.
- 2) Upon proof that both automatic isolation valves are open, the isolation valves on the lead plate and frame on the plant and building return water lines, shall be modulated open.
- 3) Upon an open indication of the isolation valves on the lead plate and frame, the building (tertiary) lead pump shall be commanded on, and the PID control loop shall modulate the VFD pump control and the 2-way isolation valve to maintain the differential pressure set point of the furthest coil on the system.
- 4) 2-way valves on coil chilled water flow will be modulated to meet air handler discharge temperature.
- 5) The plant side (secondary) lead pump shall also be started when the building side pump proof is made. The plant side PID control of the pump speed and 2-way valve control shall modulate to maintain a flow rate that is 5% greater (adj.) than that being maintained on the building side.
- 6) When the plant side pump speed is greater than 50% (adj.), for 15 minutes (adj.), the lag plate and frame shall be enabled and the isolation valves shall be modulated open. It shall remain enabled until the cooling enable flag is turned off or the pump speed goes below 48% (adj.) for a period of 15 minutes (adj.) when the cooling enable flag is reset.
- 7) When the outside air temperature goes 2°F below the enable temperature, the pump shall be commanded off. Upon proof that the pump went off, all automatic isolation valves shall be closed.
- 8) There shall be timers to track the run hours of each pump and plate and frame individually.
- 9) Upon failure of the differential pressure signal or sensor on the building side, the control point shall switch to the building return water temperature sensor, and maintain a 58°F set point (adj.) at high cooling loads and 54°F at part cooling loads. An alarm flag to the Building Operator shall also be set.
- 10) Upon failure of the building side chilled water supply flow sensor or the plant side flow sensor, the plant side shall switch control points

to the plant return water temperature to the central plant. It shall maintain a 58°F set point (adj.) at high cooling loads and 54°F at part cooling loads. An alarm flag to the Building Operator shall also be set.

- 11) Makeup supply water flow shall be monitored and when it reaches 5 GPM for more than 15 minutes, an alarm flag to the Building Operator shall be set and the cooling system shall be shut down.
  - 12) Monitor flows and provide leak detection per section 2.01 B. 9. b.
- i. Indirect connect Sequence of Operation (Existing Building Systems)
- 1) When the cooling enable flag is turned on based on the outside air temperature exceeding the enable temperature, the automatic isolation valves shall be commanded open.
  - 2) Upon proof that both automatic isolation valves are open, the isolation valves on the lead plate and frame on the plant and building return water lines shall be modulated open.
  - 3) Upon an open indication of the isolation valves on the lead plate and frame, the building (tertiary) lead pump shall be commanded on, and the PID control loop shall modulate the VFD pump control and the 2-way isolation valve to maintain the differential pressure set point of the furthest coil on the system.
  - 4) 2-way valves on coil chilled water flow will be modulated to meet air handler discharge temperature.
  - 5) The plant side (secondary) lead pump shall also be started when the building side pump proof is made. The plant side PID control of the pump speed and 2-way valve control shall modulate to maintain a flow rate that is 5% greater (adj.) than that being maintained on the building side.
  - 6) When the plant side pump speed is greater than 50% (adj.) for 15 minutes (adj.), the lag plate and frame shall be enabled and the isolation valves shall be modulated open. It shall remain enabled until the cooling enable flag is turned off or the pump speed goes below 48% (adj.) for a period of 15 minutes (adj.). When the cooling enable flag is reset.

- 7) When the outside air temperature goes 2°F below the enable temperature, the pump shall be commanded off. Upon proof that the pump went off, all automatic isolation valves shall be closed.
- 8) There shall be timers to track the run hours of each pump and plate and frame individually.
- 9) Upon failure of the differential pressure signal or sensor on the building side, the control point shall switch to the building return water temperature sensor and maintain a 50°F set point (adjustable based on commissioning or test results). An alarm flag to the Building Operator shall also be set.
- 10) Upon failure of the building side chilled water supply flow sensor or the plant side flow sensor, the plant side shall switch control points to the central plant return water temperature. It shall maintain a 58°F set point on the plant return (adjustable based on commissioning or test results). An alarm flag to the Building Operator shall also be set.
- 11) Makeup supply water flow shall be monitored and when it reaches 5 GPM for more than 15 minutes, an alarm flag to the Building Operator shall be set and the cooling system shall be shut down.
- 12) Monitor flows and provide leak detection per section 2.01 B. 9. b.
- 13) If an isolation valve fails to open or close, a fault alarm shall annunciate to the BAS shop.. System should not start up until valve fault is cleared. If a VFD faults during startup or while running, the backup VFD shall start. If there is no back VFD, a fault alarm shall annunciate to the BAS shop.

**B. Common Requirements (for all systems)**

1. Installation shall comply with the Ohio State University Building Design Standards.
2. Secondary Chilled Water Pumps
  - a. In instances where existing or renovated building systems to be served from the plant have existing systems designed for a 10°F delta-T (or less), it is usually not feasible to obtain a 16°F delta-T unless these existing systems are replaced. Recognizing this, building pump selections must accommodate higher flow rates to obtain the required cooling capacity of the terminal units with the lower delta-T.

- b. All secondary pumps to be designed, procured, and installed as part of the building to be served.
  - c. All secondary and tertiary chilled water pumps are to be located and powered at the individual buildings and shall include normal and standby power (if required, see Risk Management section 2.01 B. 9.)
  - d. All pumps shall be variable speed, variable flow, and pressure pumps.
  - e. The secondary chilled water pumps shall be designed to overcome the pressure drop of the distribution piping from the plant to the buildings, **AND** to offset the pressure drop in the building chilled water piping system, including the plate and frame heat exchanger, if installed.
2. Pump Head Pressure Requirements
- a. The secondary chilled water pumps must overcome the primary loop distribution piping losses from the Chiller Plant to the building, in addition to other requirements.
    - 1) The primary loop distribution system losses have been calculated through a hydraulic analysis based on assumptions of need for all buildings to be connected to the Chiller Plant distribution loop.
    - 2) Ohio State uses KYPIPE software to maintain Ohio State's existing distribution systems. The campus hydraulic analysis has been predicted by a KYPIPE hydraulic model and will be maintained by Utilities for the life of the chilled water systems.
    - 3) The design engineer for any building to be connected to the plant is required to determine the building needs and consult with Utilities to determine variances (if any) from the estimated flow requirements used in the model.
    - 4) OSU Utilities will model new buildings and inform the design engineer of the required pressure drop between the chilled water supply and return connection points for the maximum building flow. The building design engineer will determine the pump head requirements to meet the connection point pressure drop plus the pressure drop through all building equipment.
  - b. Modeling is based on full system flow rates including future connections.

3. Secondary Loop and Tertiary Loop Chilled Water Pump Selections

The number and sizing of the building secondary loop and, if required, tertiary loop chilled water pumps to be provided for each building shall be based on:

- a. If three chilled water pumps are provided, each loop pump shall be capable of delivering at least 50% of the maximum expected flow.
- b. If two chilled water pumps are provided, each loop pump shall be capable of delivering 100% of the maximum expected flow.

4. Emergency Isolation Valves

- a. Where specified for emergency isolation, actuated valves on the building chilled water supply and return shall be provided to isolate the building piping system from the distribution loop. The valves shall be located just inside the building in an easily accessible location.
- b. Where specified for emergency isolation, actuated valves shall be provided on the tertiary chilled water supply and return piping.

5. Chilled Water Cooling Coils

- a. Coils to be selected and sized to perform all cooling functions with the design chilled water supply temperature and the design chilled water delta-T (16°F).
- b. The plant supply temperature is 42°F chilled water to the building. If the building has a plate and frame heat exchanger, tertiary design supply water temperature should be 45°F with a 16°F delta-T. Coils of the air handler units shall be selected for a supply temperature of 45°F and a delta-T of 16°F.
- c. The plant is intended to operate with a 16°F chilled water delta-T. All future renovations of buildings will require 16°F delta-T cooling coil selections, designed for not less than 42°F for direct connections and 45°F with the plate and frame heat exchanger.

6. Air Removal

An air and dirt separator shall be provided for each building distribution system. Automatic or manual air vents will be required at all high points in each system. Air vents must have manual isolation valves to permit replacing a failed vent without shutting down the system.



7. Piping and System Components

a. Minimum Pressure Ratings

- 1) The pressure rating of all components used in the building's chilled water system must be suitable for the maximum of system static pressure and system operating dynamic pressures.
- 2) All chilled water system components shall have at least 150 PSIG rating. Note that some building design applications will require components rated at pressures higher than 150 PSIG.

b. Plant, System Distribution and Direct Connect Building Piping

- 1) All building chilled water systems will be designed for variable flow, without bypass, to obtain maximum delta-T from the chilled water.
- 2) Direct connect building piping shall comply with Division 33 Chilled water Distribution Piping Requirements in the Building Design Standards.
- 3) Taps for new building service will be addressed on a case-by-case basis as negotiated between the building Client and Utilities.
- 4) Provide provisions in the design for stress, expansion, and contraction.
- 5) Isolation valves are required to isolate all pumps and heat exchange devices for service.
- 6) All entering and leaving piping from each pump and heat exchange device to have pressure and temperature taps (P&T plugs).
- 7) All devices piped in parallel to have balancing valves, except variable speed drive pumps.
- 8) Pumps shall be provided with sufficient turn-down to account for minimum flow conditions. Minimum pump flow operation characteristics shall be approved by Utilities.

c. Valves – Secondary and Tertiary

- 1) All control valves used in the secondary and tertiary chilled water system must be modulating, 2-way control valves. The intent is to limit chilled water flow to only what is needed and to maximize the efficiency of the system.
  - 2) Provide proper valve features as determined by the manufacturer for the design and installation requirements.
  - 3) Shutoff Valves – All shutoff valves shall be bi-directional double offset design with flange end connections.
- d. Equipment and Piping Support
- 1) Provide hangers, supports, concrete inserts, and support accessories required for installed piping and equipment.
  - 2) For plant and distribution, piping supports and parts shall conform to ASME B31.1.
  - 3) For plant, distribution, and secondary piping, provides provisions in the design for stress, expansion, and contraction. Thermal stress analysis of new chilled water piping systems shall be performed by the A/E and must be submitted to Utilities for review, acceptance, and filing.
- e. Strainers
- 1) Construction and Start-up strainers shall be specified at a minimum of 40 mesh and are required on each pump
  - 2) Permanent duty strainers shall not exceed 20 mesh.
  - 3) Permanent strainers shall be installed to protect pumps and plate and frame heat exchangers.
- f. Inspection and Startup Requirements
- 1) The engineer of record, in association with the commissioning agent (if applicable) and coordinated with Utilities, shall develop an inspection, flush, and startup plan.
  - 2) Each contractor shall be responsible for the integrity their own welds. Third-party inspection of all welds shall be in accordance with the State of Ohio Piping Code.

- 3) Each contractor shall perform their own hydrostatic test.
- 4) Cleaning, Flushing, and Water Treatment:
  - a) Each contractor shall flush, fill and treat their system before being connected to the distribution system.
  - b) The initial filling of the building system from the plant distribution system is prohibited to prevent damage to the Central Plant equipment and /or introduce air to the Central Plant system.
  - c) Each contractor shall install all bypasses necessary for flushing. This contractor shall also remove bypasses to a permanent configuration when flushing is complete.
  - d) For initial building system start-up, the system shall be pumped by building system pumps for flushing.
  - e) After start-up all plant side chilled water chemistry and make-up shall be controlled at the Central chiller Plant. Tertiary side chilled water chemistry and makeup shall be controlled by the building facilities staff.
  - f) Utilities will sign-off on the water chemistry before any valves being opened.
- 5) Complete system balance and commissioning (Section 2.01 C. and D.)
- g. Country of Origin and Fabrication
  - 1) All piping, fittings, valves, valve components, and piping accessories to be manufactured, and/or assembled in the United States of America or Canada, except as noted below.
  - 2) Any manufacturing or fabrication outside of the United States or Canada must be manufactured, fabricated, and/or assembled by an ISO 9001 registered corporation. Submit ISO 9001 registered certificates.
  - 3) No piping, fittings, and piping accessories manufactured, fabricated, and/or assembled in China, including Taiwan will be permitted.

8. Chilled Water Metering

- a. The main chilled water supply meter shall conform to the Hydronic Energy Distribution Standard, DIV 33 Section 33 61 33 of the Ohio State Building Design Standards. Hydronic Energy Distribution Meter installations shall be reviewed and approved by Utilities. The flow meter and temperature signals shall be accessible to Utilities for remote monitoring purposes. Instep eDNA is acceptable method for monitoring.
- b. Building and leak detection flow meters shall meet Project specifications.
- c. Shared sensors between metering and building controls are not allowed.

9. Risk Management Issues

- a. Loss of Power: Central chilled water is not normally available during a utility power outage. The exception is the Wexner Medical Center which provided for standby electrical generation to support critical cooling loads out of the South Chiller Plant (see section 12 below).
- b. Leak Detection: Evaluate the risk of building system leaks and specify detection where directed as follows:
  - 1) Tertiary Chilled Water System
    - a) If the tertiary chilled water system make-up water flow meter exceeds 5 gpm (adjustable) for greater than 10 minutes (adjustable), a high flow suspected leak alarm will be sent for facilities staff immediate action.
    - b) (Where specified) Monitor flows and if the supply and return flows differ by 10% (adjustable) for a period of 5 minutes (adjustable), shutdown the building system pumps and modulate close the building system isolation valves, preventing water hammer. Send an alarm flag to the Building Operator.
  - 2) Building Chilled Water Leak Detection Systems (where applied)
    - a) Monitor supply and return flows. If the secondary chilled water supply flow is greater than the secondary chilled water return flow back to the Chiller Plant by 10% (adjustable) for 5 minutes (adjustable), or either flow device reads a negative flow for the same period, stop the building pumps and modulate close the isolation valves on the supply and return

pipng from the plant, preventing water hammer. A high flow suspected leak alarm will be sent for facilities staff immediate action. In buildings with 24/7 staffing the Leak Detection shutoff can be manually initiated instead of automatic.

- b) The secondary chilled water supply and return motor actuated isolation valves shall be located just inside the building in an easily accessible location.

10. Building Interfaces

- a. The facility shall be provided with an interface to the Instep eDNA server for metering process and monitoring through Instep. See Section 33 61 33 of DIV 33.
- b. Sequences of Operation shall be in accordance with this guideline, developed by the A/E, and submitted to the University and the Commissioning Agent for review and approval.
- c. The building chilled water pump speed controller shall be controlled and connected to a local Building Automation System and monitored by the Building Operator.

11. Building & Plant Chilled Water Supply and Return Temperature Optimization

- a. Central Plant efficiency is heavily influenced by the supply and return water temperatures, to and from the building. If buildings are over pumping, the central plant must operate additional pumps, chillers and cooling towers, increasing purchased electrical costs by more than \$100/hour for a 2000-ton chiller.
  - 1) Supply water temperature will be as required to satisfy the building, considering space temperatures and dehumidification needs.
  - 2) Return water temperature will be a function of plate and frame heat exchange and cooling coil performance.
  - 3) Cooling capacity of the chilled water is often underutilized, over pumping occurs and low return temperatures result.
  - 4) As a general guideline, return temperatures less than 54°F in the summer and 50°F in the winter are an indication that building

cooling system is underperforming and lowering central plant efficiency.

- b. Short term over pumping may be required to meet building loads, but should be addressed promptly.
  - d. Monitor and alarm supply and return temperatures, notifying operations of potential malfunctions, and permitting investigations and remedial actions.
  - e. Metering and billing procedure shall address the cost of over pumping.
12. South Campus Standby Chilled Water Signaling
- a. With 5000 tons of standby chilled water production available at the South Campus plant, it is necessary for connected facilities to shed load in the event of standby chilled water production. As of this revision of this document, 4,000 Tons are allocated to the Cancer and Critical Care Tower (CCCT) and 1,000 Tons are allocated to Ross Heart Hospital.
  - b. Upon a full power failure, the Chiller Plant will initiate the standby chilled water production sequence. The plant operators will confirm the plant is in fact under standby chilled water production and initiate the standby chilled water production signal. This manual intervention is intended to prevent nuisance interruptions for the chilled water clients. Upon a return of utility power, Utilities High Voltage Services will de-energize the standby generators and the plant operators will disable the standby chilled water production sequence and control signal.
  - c. The South Chiller Plant PCS shall generate a 120 VAC signal. The Wexner Medical Center Campus has a relay located in the CCCT medium voltage room on the 1<sup>st</sup> Floor. Multiple normally open dry contacts are provided for the Building Automation System to pick up and initiate the appropriate actions at their respective facilities. A second set of cables are located in a junction box near the chilled water distribution valves for the 12<sup>th</sup> Avenue tunnel for future connections. Buildings connected to this section of the distribution will be required to extend this cabling, install a utilities approved relay in an approved location.
  - d. Upon closing of the contacts, the standby sequence shall be initiated. All buildings other than those designated to receive standby chilled water shall stop all secondary pumps and close all building isolation valves. Upon opening of the contacts, the connected buildings shall begin their own start-up sequence for chilled water usage.

C. Test, Adjust, and Balance (TAB)

1. TAB Contractor's Requirements

- a. Work under contract and management of the Engineer of Record or the Commissioning Agent.
- b. Act and perform as an extension of the commissioning program in form and in intent.
- c. Act in the best interests of the University.
- d. Be unaffiliated, directly or indirectly, with any contractor on this project.
- e. Provide test results and recommendations for any corrections needed.
- f. The TAB Contractor must be certified by:
  - 1) American Air Balance Council (AABC),
  - 2) National Environmental Balancing Bureau, Inc. (NEBB).

Qualified in the disciplines specific to the project applications and needs, and able to make recommendations for balancing of air and water systems.

2. Balancing Devices

The design shall provide balancing valves for each parallel flow device and all other devices that requires a water flow balance.

3. Required TAB Preparation

Before balancing, complete the following:

- a. The hydronic systems shall be circulated and shall be determined to be internally clean and leak-free.
- b. The hydronic system contractor shall remove the startup strainer and install a clean permanent strainer.
- c. Remove air from all high points in the system and at all coils.

- d. Verify system static pressure 10 psi or greater at the highest point in the system.
- e. Set system differential pressure to lowest level with all devices open and with adequate flow to the most restricted portion of the system.

4. Reporting

- a. Interim balance reports (orally and in written format) may be required anytime during the course of testing.
- b. Provide three copies of the final balance report indicating:
  - 1) Pump curves with operational points plotted.
  - 2) Specified and actual performance.
  - 3) Verification of equipment performance.
  - 4) Investigation (within the capabilities of a TAB contractor) with recommendations for any variation from specified conditions.

D. Commissioning

- 1. Definition by ASHRAE as a systematic process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.
- 2. Building commissioning shall be provided:
  - a) to ensure that the building chilled water systems are designed and function in accordance with this Basis of Design
  - b) Initial filling of the building system shall be metered to obtain a total building system chilled water volume. Document and submit this total water volume to the project's Commissioning Agent.
  - c) by an independent third party hired by the University.



E. Responsibility Matrix

1. Responsibility for the various design, startup and maintenance activities associated with the equipment described in this document is a shared responsibility among business units at OSU.
2. Refer to Figure 4 at the end of this document for a matrix of responsibilities.

Figure 1

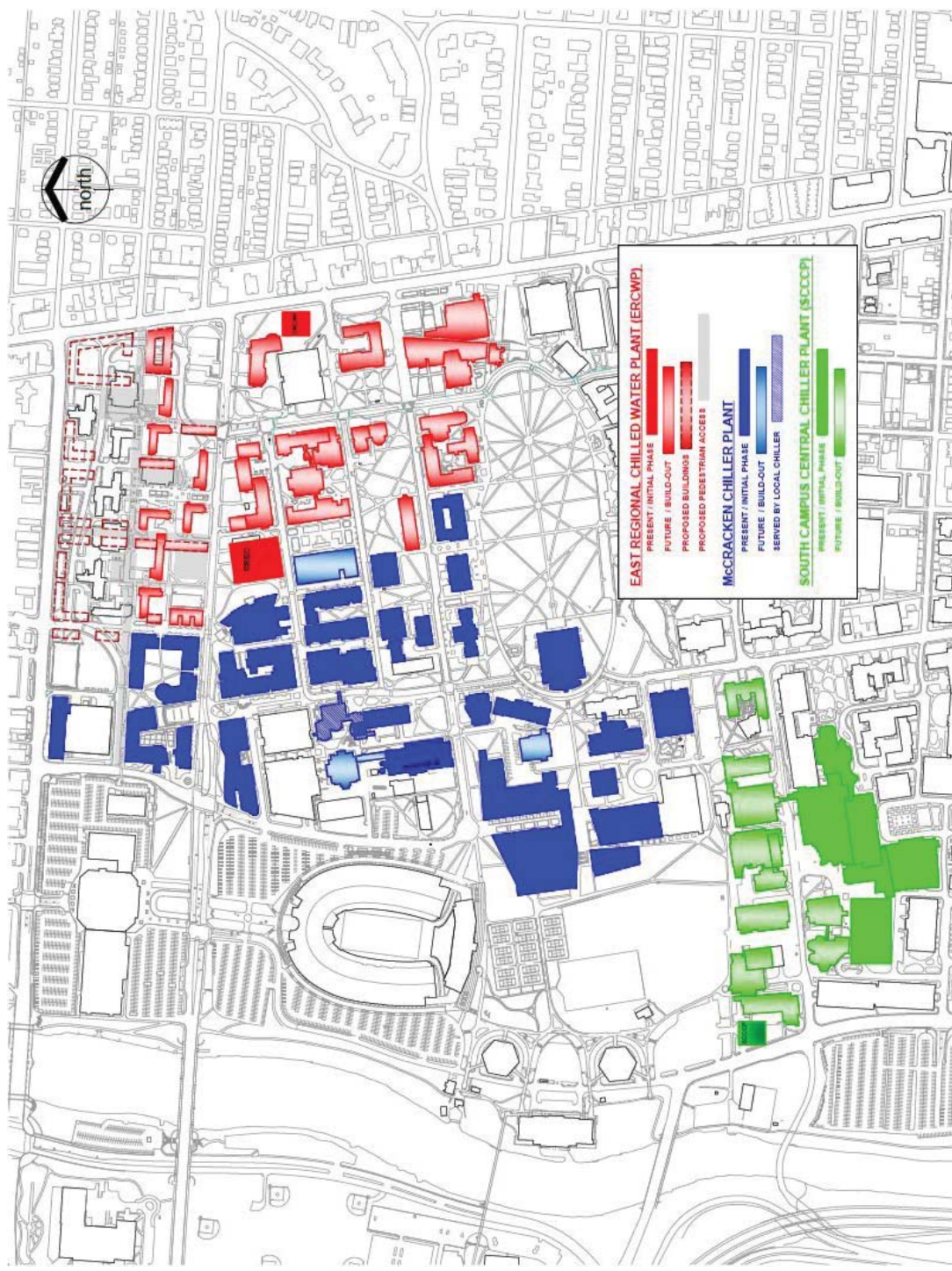
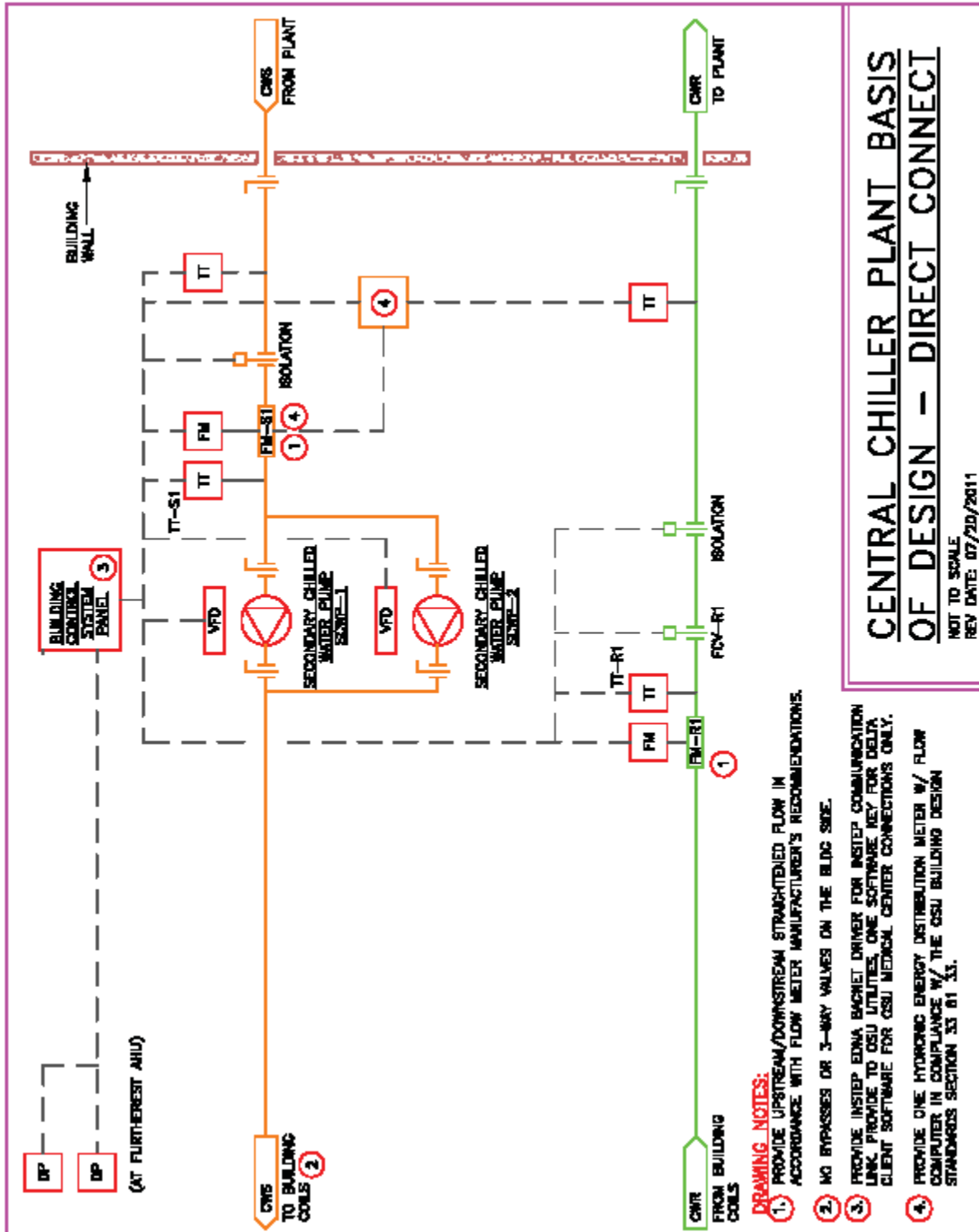


Figure 2



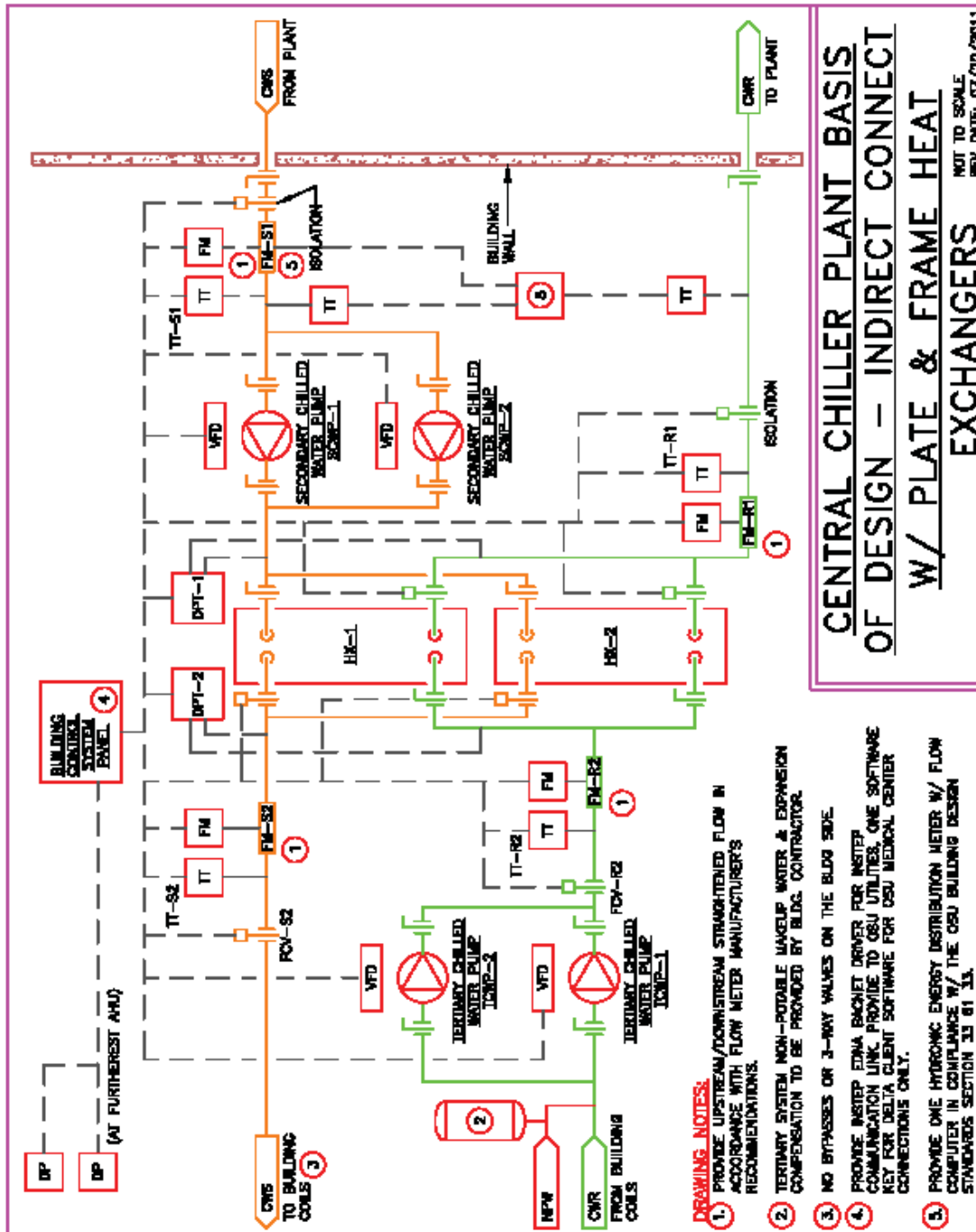


Figure 4

**CHILLED WATER SYSTEM RESPONSIBILITY MATRIX**

ITEM	FOD Utilities	FOD ESS	Building Operator	FOD FDC
Central or Regional Plant Chillers Operation and Maintenance	P			
Central or Regional Plant Cooling Tower Operation and Maintenance	P			
Central or Regional Chilled Water Loop Water Treatment	P			
Central or Regional Plant Tower Water Treatment	P			
Central or Regional Plant Chilled Water System Distribution Piping to Building Shutoff Valve	P			
Loop Chilled Water Supply Temperature Control	P			
Central or Regional Plant Internal Flow Meters	P			
Distribution chilled water piping fill and flush at startup	A		A	P
Building chilled water metering and billing		P		
Direct Connect Secondary Chilled Water Pumps and strainers			P	
Direct Connect Secondary Chilled Water Pumps and Flow Controls			P	
Direct Connect Process Load Control and Sequence			P	
Direct Connect Building Piping after Shutoff Valve			P	
Indirect Connect Secondary Chilled Water Pumps and Strainers			P	
Indirect Connect Secondary Chilled Water Pumps and Flow Controls			P	
Indirect Connect Plate and Frame Heat Exchanger			P	
Indirect Connect Tertiary (Building) Makeup Water			P	
Indirect Connect Tertiary Chilled Water Pumps and Strainers			P	
Indirect Connect Tertiary Chilled Water Pumps and Flow Controls			P	
Indirect Connect – Water Treatment on Building Side of Plate and Frame Heat Exchanger			P	
Building Chilled Water Cooling Coils			P	
Building piping fill and flush at building startup	A		A	P
Building Return Temperature Optimization	A		P	
Design and commission chilled water load shedding (where supplied)	A		A	P
Building Emergency Isolation Valves (where supplied)			P	
Leak Detection (where supplied)			P	

KEY:  
P - Prime Responsibility  
A - Assist  
FOD - Facilities Operations and Development;  
ESS - Energy Services and Sustainability  
FDC - Facilities Design and Construction  
Building Operator - group having responsibility for operation and maintenance of building systems

## **Appendix H – Utility Service Connection and Inspection Standards**



## **Procedure Statement**

Per agreement with ODIC, FOD Utilities Division is the AHJ for Columbus campus utility infrastructure. FOD Utilities include chilled water plant equipment and pipelines for chilled water supply from and return to McCracken Power Plant, the South Campus Central Chiller Plant, and the East Regional Chilled Water Plant; steam and condensate plant equipment and distribution pipelines for steam supply from and condensate return to McCracken Power Plant; associated utility tunnels and trench-boxes; domestic cold water distribution, fire hydrants; and natural gas distribution.

Campus electrical substations and primary electric service equipment is utility infrastructure covered in a separate document: Primary Electric Service Procedure available at [fod.osu.edu/utilities/links.htm](http://fod.osu.edu/utilities/links.htm).

As AHJ, FOD Utilities will inspect and authorize new or renovated utility services before start-up to verify systems comply with federal regulations, state codes, and university standards.

This procedure defines the internal FOD review and AHJ inspection procedures necessary to manage the risk associated with construction of new or renovated utility piping systems and connections. The goal of this procedure is to ensure that new or renovated utility service construction meets the safety and reliability requirements defined in the university Building Design Standards, AWWA, Gas Pipeline Safety, ASME Pressure Piping, and applicable state and national codes.

Compliance with this procedure is a required component of the mitigation strategy to the risks that improperly installed utility systems pose of injury or fatality to employees, contractors, students, or visitors and of utility service interruptions to critical Medical Center, research, animal care, student housing, and other university operations.

## **Definitions**

1. ASME – American Society of Mechanical Engineers
2. AWWA – American Water Works Association
3. AHJ – Authority Having Jurisdiction
4. BDS – Building Design Standards for The Ohio State University
5. Building service connection – The custody transfer point between FOD Utilities or other utility company and the building operator defining the responsibility limits for each party.
6. ODIC – Ohio Division of Industrial Compliance
7. FDC – Design and Construction
8. FOD – Facilities Operation and Development
9. OSU Distribution System - Pipelines and valves in the OSU utility distribution systems located:
  - a. downstream from the meter and tap into the City of Columbus Water System and upstream of building service connections
  - b. buried or tunnel/trench box installed 200 psig superheated steam piping between McCracken Power Plant and the building service connection
  - c. buried or tunnel/trench box installed chilled water distribution system piping between central chilled water plants and the building service connection
10. OSU Master Meter System – The natural gas pipeline systems downstream from the Columbia Gas regulator, meter station that supply more than one building service connections.
11. Qualified Technical Personnel – An individual who by licensing, qualification, certification, or experience has been designated as an inspector.
12. Repair – A maintenance type repair in kind, and matching the original materials and design, described by work place procedures.



13. Renovation – A system repair or renovation that changes the design or equipment and requires qualified design oversight and inspection.

## **Requirements**

This procedure applies to any facility supplied utilities from the Columbus campus FOD Utilities distribution or master meter systems. Service connections that tie directly to City of Columbus or Columbia Gas of Ohio distribution systems shall comply with the service provider's requirements. Primary Electrical Service procedures and checklists for OSU 13.2 KV electrical grid connections were first issued in October 2008 and exist as a standalone procedure, available for download at [fod.osu.edu/utilities/links.htm](http://fod.osu.edu/utilities/links.htm).

Utility systems shall conform to The Ohio State University Building Design Standards (BDS) as stipulated in Division 33 of that document (or in an approved Division 33 variance) and further clarified or defined in documents referenced therein. Utility Service to such facilities is under the control and at the discretion of FOD Utilities Division as AHJ for central utility systems.

The Architect/Engineer of Record (A/E) shall consult on the design intent with FOD Utilities regarding the sizing and configuration of the utility service. See Utility service request at [fod.osu.edu/utilities/files/request.doc](http://fod.osu.edu/utilities/files/request.doc).

FOD Utilities, in consultation with the A/E, shall establish the connection point for each required service during schematic design and before design development, based upon a careful evaluation of building service requirements, capacity in the central plants and distribution systems, and what is appropriate for the campus systems.

Utility system installations are inspected against construction permit documents and for compliance with the BDS. For conventional Design/Bid/Build projects, the permit drawings are typically the Conform Set of construction documents. Design Build projects shall provide a permit set of utility construction documents for FOD Utilities' use and review, as early in the design build as possible and not less than four weeks before inspection and start-up is anticipated.

ODIC, as AHJ for building systems, performs inspections for new building construction. In general, FOD Utilities inspections are focused on utility distribution and interconnected piping systems within buildings. ODIC inspections are focused on building code compliance and life safety systems. Any new or renovated campus building mechanical systems that connect to utility infrastructure will require both FOD Utilities and ODIC inspections.

Utility Service Connections are subject to inspection and denial of services for any non-conforming or substandard installations in accordance with published requirements. Utilities shall place the security of the utility system, safety, and the long-term continuity and reliability of service for the entire university over the preferences or operational concerns of any one facility or complex.

Utility inspection procedures and checklists for chilled water, steam, domestic cold water, and natural gas service are part of this procedure and are available at [fod.osu.edu/utilities/links.htm](http://fod.osu.edu/utilities/links.htm). See separate Primary Electric Service Procedure for electrical checklists. The existence of an approved checklist and service authorization shall not relieve the equipment manufacturer or installation contractor of their warranty responsibilities, nor shall it relieve the Architect/Engineer of their design responsibilities as Engineer of Record.





## **Responsibilities**

### A. FOD Utilities

1. Oversee system maintenance repairs and renovations; determine when repair work becomes a renovation that requires qualified design oversight and inspection.
2. Maintain mechanical distribution system models (natural gas, domestic cold water, chilled water, high pressure steam, and condensate).
3. Perform all valve operations on the Ohio State distribution system to isolate for new service connections or installation of any new distribution system components.
4. Respond within minimum inspection timelines in Section D below.
5. Review and/or inspect shop fabricator and installer qualifications, procedures and quality assurance processes and maintain associated documentation.
6. Review construction records and documentation, e.g., weld maps.
7. Inspect per inspection checklists and referencing published design standards, regulations, codes and project construction documents.
8. Review the inspection results and any required ODIC permit inspections, complete documentation, sign off inspection form, and authorize service and if the installation meets the appropriate standards and no substandard practices, workmanship or non-conformant conditions are discovered.
9. Complete system in-service operating inspections to determine if system operation and building controls are within standards after startup.

### B. Design and Construction (FDC)

1. FDC shall communicate this procedure and the requirements herein to the A/E and the Construction Contractors for FDC-managed projects.
2. FDC shall coordinate design requirements with the customer(s), A/E, Contractors, Construction Managers at Risk, and FOD Utilities. FDC shall coordinate and document planned Utility outages in accordance with the Utility Outage Procedure ([fod.osu.edu/utilities/files/utility\\_outages.pdf](http://fod.osu.edu/utilities/files/utility_outages.pdf)).

### C. Architect/Engineer of Record

1. Complete Utility service request form for new or renovated utility services ([fod.osu.edu/utilities/files/request.doc](http://fod.osu.edu/utilities/files/request.doc)).
2. Submit a permit set of drawings and specifications to FOD Utilities for use in AHJ inspections and startup service approvals.
  - i. Design bid build and Construction Manager at Risk projects shall provide a construction conform set.
  - ii. Design build projects shall provide a permit set of construction documents for Utilities review. The documents shall be made available at least four weeks before anticipated service start-up.
3. Include design of temporary utility services for construction site facilities in design/permit documents.
4. Complete stress analysis for steam and steam condensate systems over 15 psig in accordance with ASME and pressure piping codes.
5. Complete stress analysis for main chilled water supply and return headers.
6. Specify system testing requirements for a new or renovated facility to demonstrate that the installation and disinfection of domestic water systems meets requirements and within accepted standards before placing in service.
7. Specify hydrant and fire pump flow testing and acceptance criteria.
8. Provide equipment submittals on utility equipment to FOD Utilities for review.
9. Perform site inspections and other Construction Administration duties as contracted.



D. Construction Contractors

1. Maintain and make available up-to-date documentation, including equipment specifications, purchase requisitions, bills of lading, and manufacturers' drawings adequate to demonstrate to university representatives that all materials and supplies used on the utility systems installation meet Building Design Standards.
2. Maintain and make available to university representatives the required certifications and qualifications of all contractor personnel involved in performing construction work:
  - i. Pressure piping welds
  - ii. Gas pipeline work
  - iii. Others as specified in contract documents
3. Obtain and post in a conspicuous and safe place on the job site all required State of Ohio certificates of final plan approval (building permits).
4. Maintain and make available during construction progress the AS-BUILT documentation to reflect the actual installed conditions of the project.
5. Provide installation and testing schedules and site access for FOD Utilities to inspect utility systems and equipment during the construction and testing process.
6. When required and with at least two week notice, provide procedure for pipeline flushing to FOD Utilities for review and approval. Provide notice and access to FOD Utilities to witness flushing activities.
7. Remove and replace, at the Contractor's expense, any work done or materials used that inspection identifies to be in violation of construction documents and specifications, except for buried equipment as described in Item #8.
8. Provide advance notice of at least 5 days and an inspection window of at least 4 hours before covering buried equipment and pipelines with fill. If this notice is not given and if FOD Utilities requests, based on a lack of other documentation or approved inspections, the contractor shall remove or uncover such portions of the work as directed to allow FOD Utilities to complete inspection. The uncovering or removing of fill and the replacing of the covering and restoration of the parts removed shall be at the Contractor's expense.
9. Provide a minimum 2-week advance notification of their intention to make tie-ins and follow the utility outage procedure.
10. Provide a minimum notice of at least two weeks before a request for final inspection and initiation of utility service.
11. Have the temporary construction service or permanent facility service inspected by the ODIC Inspector.
12. Make ODIC inspection results, signed Certificates of Final Plan Approval, and records related to utility infrastructure available to FOD Utilities.
13. Correct building operating control issues identified in operating system inspections that are in conflict with the design or sequence of operations that cause unstable or excessive demands on utility systems.

**Resources**

For questions and consultation, contact the Senior Director of Utilities (614-292-4509) or Utilities Technical Director (614-247-2489).



Inspect and document Steam Service Connections by the following checklist.

General																									
Project Name	Engineer of Record																								
Project Number	General Contractor																								
Project Manager	Mechanical Contractor																								
Steam Lateral / Underground Piping / Tunnel Piping																									
<p><b>Records Review</b></p> <table style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="width:80%;"></th> <th style="width:20%; text-align: center;">Initial Date</th> </tr> </thead> <tbody> <tr><td><input type="checkbox"/> Steam flow modeled and reviewed</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> Welding Certificates meet requirements and on file</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> ANSI/ASME B31.1 piping stress analysis submission reviewed and on file</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> Weld Non-Destructive Test reports reviewed and on file</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> Hydrostatic test records complete, filed</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> Pipe materials Material Test Records on file and meet specifications</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> Submittals have been submitted for anchors, exp jts, guides, etc.</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> A/E review &amp; authorization to put in service received</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> Commissioning Agent authorization to put in service received (if applicable)</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> Steam blow plans submitted and approved</td><td style="text-align: center;">_____</td></tr> <tr><td><input type="checkbox"/> seismic design submitted</td><td style="text-align: center;">_____</td></tr> </tbody> </table> <p><b>Post Startup and Warm-up Inspection</b></p> <p><input type="checkbox"/> Verify slides and guides operated as predicted and insulation has not been damaged by expansion</p> <p><input type="checkbox"/> Anchors – no movement, distortion, or weld cracks observed</p> <p><input type="checkbox"/> Service test and no observed leaks</p> <p><input type="checkbox"/> Traps operating and in normal temperature range</p> <p><input type="checkbox"/> Confirm re-torque of bolts after energized</p> <p><input type="checkbox"/> Pressure, temperature gauges and metered flow in expected range</p>		Initial Date	<input type="checkbox"/> Steam flow modeled and reviewed	_____	<input type="checkbox"/> Welding Certificates meet requirements and on file	_____	<input type="checkbox"/> ANSI/ASME B31.1 piping stress analysis submission reviewed and on file	_____	<input type="checkbox"/> Weld Non-Destructive Test reports reviewed and on file	_____	<input type="checkbox"/> Hydrostatic test records complete, filed	_____	<input type="checkbox"/> Pipe materials Material Test Records on file and meet specifications	_____	<input type="checkbox"/> Submittals have been submitted for anchors, exp jts, guides, etc.	_____	<input type="checkbox"/> A/E review & authorization to put in service received	_____	<input type="checkbox"/> Commissioning Agent authorization to put in service received (if applicable)	_____	<input type="checkbox"/> Steam blow plans submitted and approved	_____	<input type="checkbox"/> seismic design submitted	_____	<p><b>General Inspection</b></p> <p><input type="checkbox"/> Equipment locks and tag-out have been turned over to Utilities</p> <p><input type="checkbox"/> Construction materials and worksite has been cleaned up</p> <p><input type="checkbox"/> Piping drained following hydro-test</p> <p><b>Mechanical/Piping Field Inspection</b></p> <p><input type="checkbox"/> Confirm piping installation matches stress analysis</p> <p><input type="checkbox"/> Confirm pipe size matches installation drawings and model</p> <p><input type="checkbox"/> Confirm that all pipe supports and bolting are in place per plan</p> <p><input type="checkbox"/> Inspect anchor supports, bolting and welds (un-insulated)</p> <p><input type="checkbox"/> Wall penetrations have adequate room for expansion</p> <p><input type="checkbox"/> Inspect steam flange bolts installed as specified</p> <p><input type="checkbox"/> Gaskets meet specification</p> <p><input type="checkbox"/> Confirm that shipping bars on expansion joints are removed</p> <p><input type="checkbox"/> Inspect valves, steam traps, gauges and y-strainers</p> <p><input type="checkbox"/> Confirm that valve stem on rising stem valves are lubricated</p> <p><input type="checkbox"/> Inspect valve gear boxes for lubrication</p> <p><input type="checkbox"/> Confirm that all equipment tags/labels are installed</p> <p><input type="checkbox"/> Inspect meter installation</p> <p><input type="checkbox"/> Verify meter configuration programming and communications</p> <p><input type="checkbox"/> Confirm that specified insulation is installed on piping and valves</p> <p><input type="checkbox"/> Piping seals through structural penetrations not leaking</p> <p><input type="checkbox"/> Insulation &amp; jacketing installed (un-insulated anchors to allow for inspection)</p> <p><input type="checkbox"/> Products &amp; equipment installed in field match submittals</p>
	Initial Date																								
<input type="checkbox"/> Steam flow modeled and reviewed	_____																								
<input type="checkbox"/> Welding Certificates meet requirements and on file	_____																								
<input type="checkbox"/> ANSI/ASME B31.1 piping stress analysis submission reviewed and on file	_____																								
<input type="checkbox"/> Weld Non-Destructive Test reports reviewed and on file	_____																								
<input type="checkbox"/> Hydrostatic test records complete, filed	_____																								
<input type="checkbox"/> Pipe materials Material Test Records on file and meet specifications	_____																								
<input type="checkbox"/> Submittals have been submitted for anchors, exp jts, guides, etc.	_____																								
<input type="checkbox"/> A/E review & authorization to put in service received	_____																								
<input type="checkbox"/> Commissioning Agent authorization to put in service received (if applicable)	_____																								
<input type="checkbox"/> Steam blow plans submitted and approved	_____																								
<input type="checkbox"/> seismic design submitted	_____																								
Comments																									
BDS Div Compliance. <input type="checkbox"/> yes <input type="checkbox"/> no, state reason:																									
Signatures																									
Inspected by	Date	Reviewed and Approved (with conditions) by	Date																						
Final inspection (if conditionally approved) by	Date	Final Review and Approval by	Date																						
Energized by	Date	cc: Distribution Manager, Shop Supervisor, OSU Utilities Project Representative																							



Inspect and document Natural Gas (NG) Distribution Pipe and Service Connections by the following checklist.

General

Table with 2 columns: Field Name, Value. Fields include Project Name, Project Number, Project Manager, Engineer of Record, General Contractor, Mechanical Contractor.

Inspection Requirements

Records Review

Initial Date

- Checklist items for Records Review: Natural gas flow modeled and reviewed, Preconstruction purge plan submitted and approved, Post construction purge and service restoration plan submitted and approved, Construction Risk Management Plans reviewed (if applicable), Excavation permits reviewed (if applicable), Welding Certificates meet requirements and on file, Operator Certifications meet requirements & on file (F1, F2, E1, E2, etc.) See Appendix A – List of Covered Tasks, Submittal provided on the type of PE Fusion Machine to be used, Weld Non Destructive Test reports reviewed and on file, Pressure test (90 PSIG) and charted for 24 hours complete, passed, & original filed with Utilities, Pipe materials Material Test Records on file and meet Specification, Directional bore slurry submittal reviewed (if applicable), Outage notifications posted (if applicable), Hot tapping materials and procedures approved (if app.), A/E field reports reviewed & filed, A/E Review/Authorization to put in service received.

Mechanical, Piping Field Inspection

- Checklist items for Mechanical, Piping Field Inspection: OSU Utility marking has been completed before excavation, OUPS Utility marking has been completed for Columbia Gas point of service areas and/or campus boundary areas with Public Utilities, Purge completed prior to repairs/welding (if applicable), Tracer wire is continuous (no breaks) and installed, Inspect welds – visual, UT or radiographic, Buried depth of 36" minimum (Class 4 per B31.8), Confirm that survey personnel have located pipe, valves, test connections and anodes, Inspect trench bedding and backfill material (sand), Verify pipeline clearance from other utilities meets BDS, Pipe sleeves/other protection installed (if applicable), Correct slurry installation for directional bore (if applicable), Inspect pipe, Inspect pipe coating (if applicable), Inspect structural supports, bolts, anchors, Inspect valves, confirm type, and location, Inspect and confirm valve box installation, Inspect/verify insulation flanges and risers at transition points from buried to exposed inside tunnels & at buildings, Cathodic (Anode) protection sized properly and installed (if applicable), Check for shorts at cathodic test stations & record voltages (if app.), Confirm that all tags, labels are installed, Utility non-detectable marking tape is installed, Complete start-up purge by bleeding off air or nitrogen, Purge and cap completed on demo'd/abandoned piping (if applicable), Inspect meter installation – Coordinate w/ OSU ESS, Verify meter configuration programming and communications – Coordinate w/ OSU ESS.

Post Start-up Inspection for Building Gas Outages (if applicable)

- Checklist items for Post Start-up Inspection for Building Gas Outages (if applicable): Completed testing to verify building gas system is leak free, Verify and confirm w/ customer, building equipment operator to ensure proper restoration of natural gas service (gas pressure within limits, pilots relit, equipment started up).

Comments, Description of Work, Routing of Natural Gas Line

BDS Div Compliance.  yes  no, state reason:

For gas service to new or major renovation buildings, the following is required before gas service valves can be opened:

- Checklist items for gas service requirements: ODIC State Inspection completed, Records of building piping pressure tests have been provided to Utilities.

Signatures

Table for Signatures with 2 columns: Field Name, Value. Fields include Inspected by, Final inspection (if conditionally approved) by, Energized by, Reviewed and Approved (with conditions) by, Final Review and Approval by, cc: Distribution Manager, Shop Supervisor, OSU Utilities Project Representative.