ELECTROSPEED

OPERATOR'S MANUAL
October 2000

Electrospeed GCS Manual

Centrilift
CONTROL TECHNOLOGIES

Centrilift, A division of Baker Hughes

Version 4.14 Release
October 2000

Display screens and examples contained in this manual require that the Electrospeed GCS system contain the listed versions of firmware. Please contact Centrilift for system firmware updates if necessary.

System Firmware Revisions required:
Graphic Display Unit: 3.26 or higher
System Control Unit: 5.80 or higher
Power Conversion: 7.06 or higher

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INTRODUCTION

This manual contains general information regarding the GRAPHIC CONTROL SYSTEM (GCS) operating system, and specific installation, setup and operating instructions for the Electrospeed (GCS), Variable Speed Controller.

GENERAL DESCRIPTION

The Electrospeed GCS is classified as a variable voltage inverter (VVI). It uses a six-pulse silicon controlled rectifier (SCR) to convert AC power into variable voltage DC power. Drives with higher pulse count converters (identified as 12 or 18 Pulse drives) can be configured where harmonic reduction is required. A series inductor and capacitors across the DC bus are used to filter the AC ripple. The inverter uses six power IGBT transistors to synthesize a 3-phase quasi-sinusoidal output voltage using Centrilift's SelectWave™ inverter algorithm. This modern AC variable voltage inverter is designed to meet all the requirements of installations requiring a variable frequency source. It operates directly from 380 to 480 VAC 3-phase 50/60 Hertz power.

Use of the latest microprocessor technology allows for ease of set up, operation and diagnostics. "Micro" control also reduces the number of circuit boards required thus enhancing the reliability and versatility of the drive. The graphical operator interface provides ease of use and programming of special applications. The GCS is programmable for many types of loads, such as variable torque, constant torque, and constant voltage with extended speed range. The GCS control system also provides a high-speed telemetry interface (CITIBus™) that simplifies control system expansion and customization.

The Electrospeed Graphic Control System is available in two types of enclosures; weatherproof (NEMA 3, IP54) and general purpose (NEMA 1, IP33). The weatherproof units use a patented cooling system that eliminates the inefficiencies and reliability problems associated with heat pumps. Each of the two types are offered in four enclosure sizes referred to as "1000", "2000" , "4000" and "8000" series.

The Electrospeed GCS controller can communicate with SCADA or telemetry systems using the included Modbus RTU protocol and built-in RS-232 hardware interface. Input/Output expansion modules can be added to the system, to provide a single point of control and monitoring for a wide range of sensor types.

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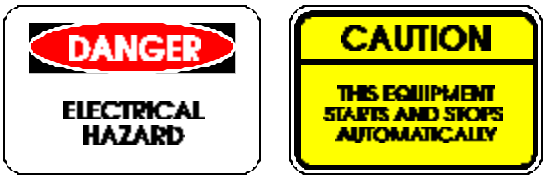
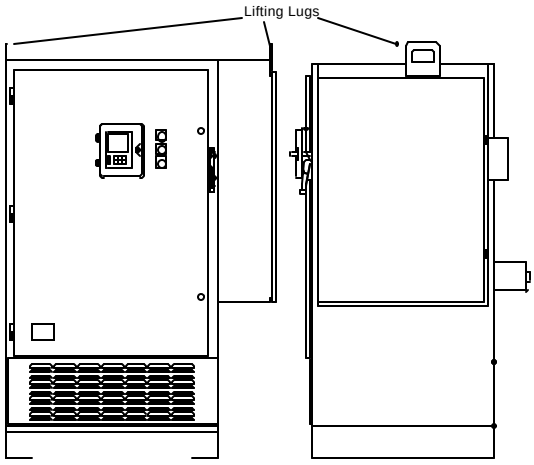
Electrospeed GCS

FEATURES/FUNCTIONS	BENEFITS
Connectivity, Telemetry ready	Allows networking or remote operation
Downloadable Configuration	Ease of multiple controller setup
Control system expandability via I/O modules	Flexibility in system design & commissioning
GCS operator interface identical for all GCS products	Maintenance and operations personnel need to learn interface only once
Surface mount electronics technology	Smaller circuit boards, with fewer connections lead to higher reliability
Field upgradable software	Controller does not have to be removed from location to modify or upgrade software
Datalogger outputs spreadsheet compatible data files	Allows monitoring and analysis of recorded data using familiar PC software tools.
Electronic Chart recorder built-in	Allows paper-less recording of motor current
Redundant backup of data and operating parameters	Reduces chance of data and protection loss due to failure.
Date / Time stamp of event and shutdown history	Helps identify problems or trends
Diagnostic / alarm windows pop up automatically	Automatic display of problems without operator security clearance
Programmable I/O	I/O can be programmed to function independently of controller operation, similar to an independent PLC
Compatible with entire GCS product line	Interfacing to and configuring other Centrilift products is made easier.
Enclosures comply with industrial standards NEMA 3, IP54, NEMA 1, IP33	Reliable operation in any environment

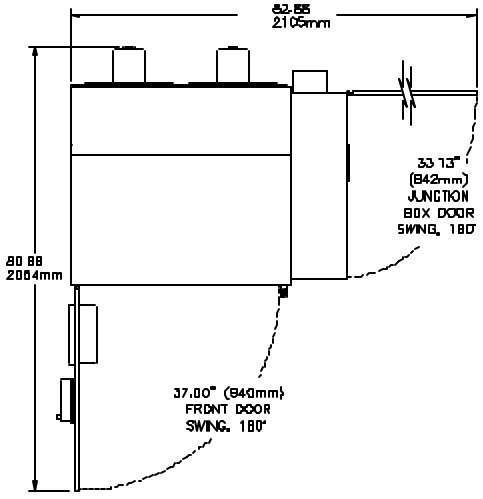
SAFETY & INSTALLATION





4000 NEMA 3, GCS

FRONT VIEW RIGHT SIDE VIEW



Top View - Actual dimensions vary with model number

SAFETY RECOMMENDATION

The controller should be installed, adjusted and serviced by qualified electrical maintenance personnel. Improper installation or operation of the controller may cause injury to personnel or equipment. The controller must be installed and grounded in accordance with local and national electrical codes. Potentially lethal voltages exist within the cabinet. Extreme care must be taken to insure all power sources are disconnected before starting installation, maintenance and repair jobs.

SHIPPING AND STORAGE

The Electrospeed controller should be securely fastened to any vehicle used to transport the unit. Use tie down ropes or straps to immobilize the unit during shipping and prevent shipping damage. To prevent damage during storage or transportation, the unit must not be stored or shipped in corrosive atmospheres. The cabinets are specially designed for safe handling using a spreader bar placed through the lifting lugs at the top of the unit. Lift capacity should be checked prior to moving the unit into place. Check Appendix A for size and weight of specific unit being installed.

INITIAL CHECKS

Before installing the controller, check the unit for:

* Physical damage to controller. Visual damage to the shipping container or cabinet.
* Remove all packing materials such as tape, foam, shipping restraints, and padding.
* Correct application. The controller nameplate data, transformers, and load must be compatible.
* Internal connections. Insure that all circuit boards, cables, components, and connectors are securely in place.

INSTALLATION OF CONTROLLER

The general purpose enclosure (NEMA 1, IP33) is suitable for most factory or control room installations, however, care should be taken in choosing the location. The area must be well ventilated to allow unrestricted air flow through the controller's filtered intake. Cooling air entry and exit is located on the front of the controller, therefore, no side, back, or top clearance is required. A minimum of 36 in. (1 m) clearance in front of the enclosure is recommended for servicing, which is also adequate for cooling airflow. Areas with oil vapors or mists, excessive

moisture, or with fumes or vapors that are corrosive or flammable should be avoided.

The Weatherproof enclosure (NEMA 3, IP54) is suitable for outdoor installations in non-hazardous locations. Allow a minimum of 48 in. (1.22 m) clearance in the front and the rear of the enclosure for servicing and air flow requirements. Never install the controller close to heat generating sources such as transformers or other controllers. It is necessary to have an unrestricted supply of cooling air (50° C maximum) to the cooling fan(s) mounted to the back of the enclosure.

POWER WIRING

Generally, cable entry is through the top on the general purpose enclosure and through the right side on the weatherproof enclosure. Additionally, the 2000, 4000 and 8000 series drives provide a junction box on the enclosure's right side for cable connections. To find the recommended power cable size, first obtain the controller fuse size from Appendix E, then use the table in Appendix D to find the recommended cable sizes based on amperage required, 40° C ambient temperature, and minimum cable temperature rating of 75°. Power wiring must be sized to meet local and national electrical codes, based on maximum ambient temperatures. Connect input power cable to terminals of the input disconnect switch (1000 series and all NEMA 1 drives) or the junction box (NEMA 3, 2000, 4000 and 8000 series drives). This controller is not phase sensitive to input power rotation. Output power cable is connected from the output terminals to the input terminals of the step up transformer when utilized or the input terminals of the electric motor.

12/18 PULSE SYSTEM INSTALLATION

When needed to minimize harmonic distortion on the utility power line, the Electrospeed GCS can be configured to use a 12 pulse converter configuration. In this configuration, an additional phase shifting transformer is used to create a 30 degree phase shift of the incoming power. The output of this phase shifting transformer is connected to the converter sections of the drive. When required, an 18 pulse converter can also be configured.

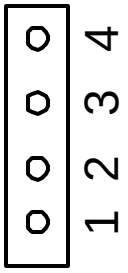
CUSTOMER INTERFACE WIRING

Factory installed control inputs and outputs are wired directly to "MOLEX" headers mounted on the System Control Board . AC control wiring should be a minimum of 14 AWG, and run in conduit separate from DC control wiring. Analog inputs (Analog 1 and 2) should be

connected with a shielded, grounded, twisted pair cable, minimum 20 AWG.

ONBOARD DIGITAL INPUTS

J28



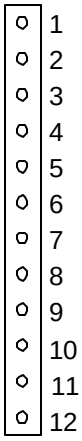
The system control board (SCB) provides three status or digital inputs defined as switch closures to ground. Inputs are terminated on SCB J28, pins 1 through 4. The pinout definitions are as follows:

Pin4 = Common, Digital Ground
Pin3 = Digital Input #3 (or Hand Mode switch)
Pin2 = Digital Input #2 (or Auto-ReStart Mode switch)
Pin1 = Digital Input #1 (or START push-button switch)

These inputs are intended for signals originating inside the GCS enclosure only. ie: PHD or MTM

ONBOARD DIGITAL OUTPUTS

J24



The system control board provides three digital outputs usually used to switch external GREEN, AMBER and RED panel lights. The terminations are located on the system control board's (SCB) connector labeled J24. All three outputs are "dry contact" , Normally Open (N.O.) relay contacts rated for 10 Amps @ 250 Volts.

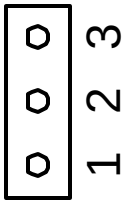
The pin connections for J24 are:

Digital 1: Pin 1 and 3 (Green "RUN" Light)
Digital 2: Pin 5 and 7 (Amber Light)
Digital 3: Pin 9 and 11 (Red Light)

Pins numbered 2,4,6,8,10 and 12 have no connections.

ONBOARD ANALOG INPUTS

J26



The system control board provides two analog inputs rated for 0-10VDC terminated on SCB J26. Interface of 4-20ma signals require the connection of a 500 ohm resistor across the "Analog input" and "Analog Ground" terminals and calibration of the offset and span parameters in the Analog input setup menus. The pinout definitions are as follows:

Pin 1 = Analog Input 1
Pin 2 = Analog Input 2
Pin 3 = Analog Common Ground

GCS BASICS

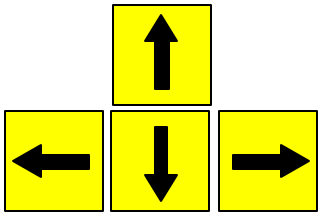
GRAPHICS DISPLAY OVERVIEW

This portion of the GCS operator's manual describes the basic principles of the Graphic Control Operating System. It also describes the operation of the keypad, the LCD display screen and all available parameters. To locate information pertaining to any specific parameter, use the index at the end of this manual to locate a keyword, then view the information on the page(s) indicated. The Electrospeed GCS controller utilizes a liquid crystal display (LCD) panel as its primary operator interface. Using this display, the operator can view and/or modify all setpoints contained in the controller. Whenever the Electrospeed GCS is first powered up, the LCD display will show the MAIN MENU screen, similar to the illustration at left.

The interface has several keypad switches whose functions are defined as follows:

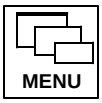
The green START key is pressed to manually start the motor.

The red STOP key manually stops the motor and is also used to clear or reset a "lockout" condition

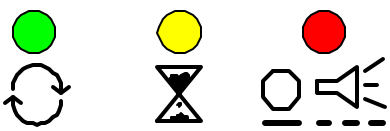


The arrow keys are used to move the cursor on the screen or to increment & decrement numbers when calibrating or editing a setpoint.

The ENTER key is used to select highlighted menu items or to program or finalize a setpoint or value entry.

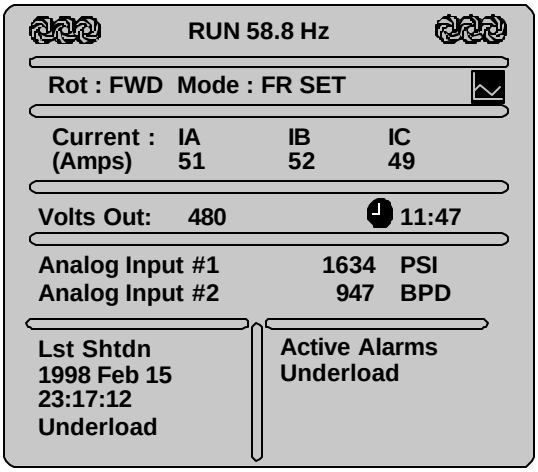


The MENU key is used as a backup or cancel key to abort any adjustment in progress. Press MENU repeatedly to access the MAIN MENU screen.

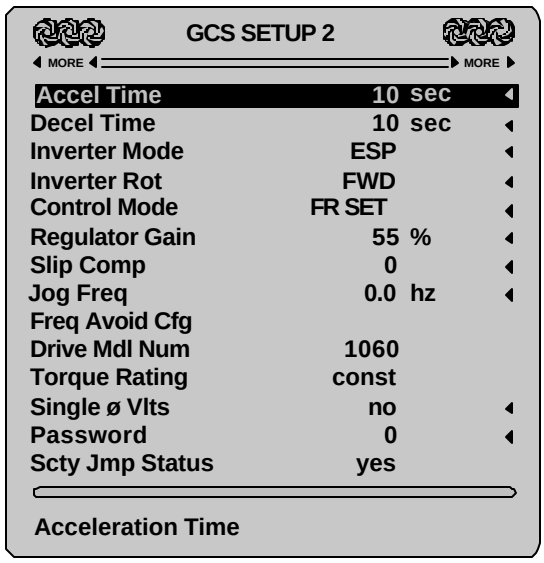


The green, amber and red panel LED's indicate the present status of the motor. Green indicates the system is running. Green with flashing Amber indicates the controller is currently timing an active alarm for a shutdown. Amber only denotes the system is stopped but all alarms are clear and it is timing down for an automatic restart. RED indicates the system is shutdown and that automatic restarts are disabled, and/or active alarms exist so that the controller will not restart by itself.

DISPLAYING A MENU, READING OR SETPOINT



The operator interacts with the Electrospeed GCS by pressing the keypad switches below the LCD display screen. Use the arrow keys to move the highlighting pointer to the desired menu item and then press the ENTER button to select that item. (Although the highlighting pointer changes in appearance depending on the information displayed on the screen, it is always implemented in "reverse color" compared to other text on screen.) As an example, to display the current operational status of the motor, use the arrow keys to move the highlight to the center "STATUS" position as shown on the previous page and press the ENTER key. The GCS will display the status screen and show running status information similar to the screen shown at left. To return back to the previous menu, press the MENU key and the display will change back to the “MAIN MENU“ screen



GCS DISPLAY CONVENTIONS

All GCS menus and screens use common symbols to convey information. For example, when a menu screen contains more information than can fit onto one page of display, the graphic ▼MORE▼ will appear at the bottom of the screen. This graphic indicates that using the arrow keys to move the cursor to the bottom of the page will cause the screen text to scroll upward until the bottom line of the menu is displayed. Several menu screens can also be linked together by the left and right arrow keys. This is indicated by the ◀MORE◀ and ▶MORE▶ graphics appearing on the left and right ends of the bar at the top of the screen. When a parameter can be modified, the small arrow pointer, ◀ appears at the right edge of the parameter’s line. Note that only some of the parameters on the example screen shown at left can be edited.

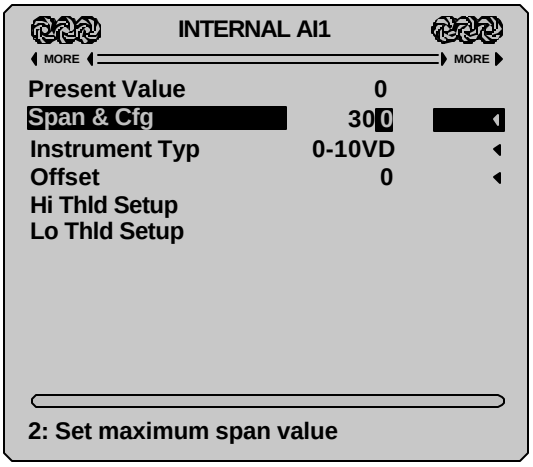
◀ This pointer at the end of the line indicates that parameter can be edited.

◀MORE◀ Indicates that additional menus can be accessed by pressing the “left” arrow key.

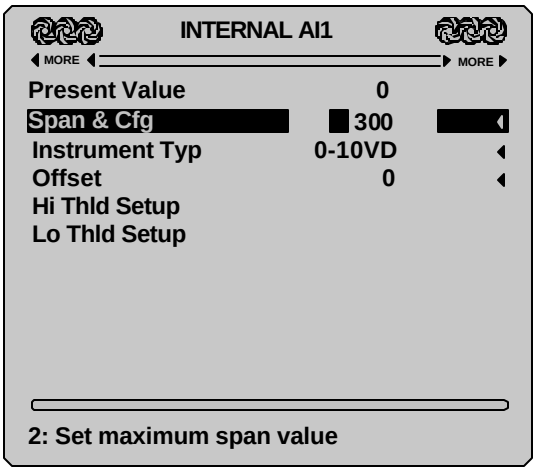
▶MORE▶ Additional menus can be accessed by pressing the “right” arrow key.

▼MORE▼ ▼MORE▼ More information or additional menu items can be reached by pressing the down arrow key and moving the cursor to the bottom of the screen.

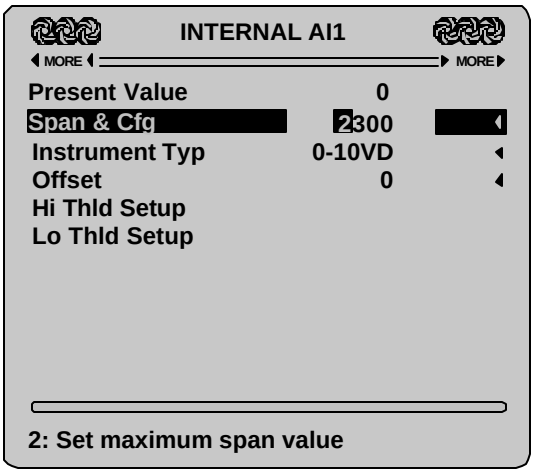
EDITING A READING OR SETPOINT



Any parameter within the Electrospeed GCS that can be edited or changed will display a small arrowhead on the right side of the cursor bar. To edit any of these parameters, use the arrow keys and the ENTER key to highlight the desired point with the cursor. When there, press the ENTER key to activate the edit mode for that point. The present value of that parameter will appear in "reverse color" as in the illustration at left. Now, pressing the up/down arrow keys will now cause that value to increase or decrease. When the reading reaches the desired value, release the arrow key, then press and release the ENTER key to save the newly modified setting. If the user wishes to abort any modifications, simply press the MENU key instead of the ENTER key to cancel the changes.

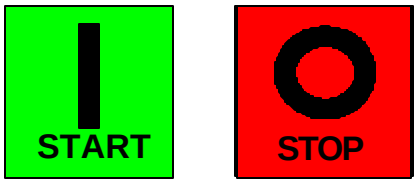


If a large number change is required, the user can use the LEFT/RIGHT arrow keys to shift the cursor to the appropriate digit location and then use the UP/DOWN arrow keys to change that digit. As an example, the illustrations at left show the steps taken to change the Analog Input #1 Maximum Span setpoint from 300 to 2300.



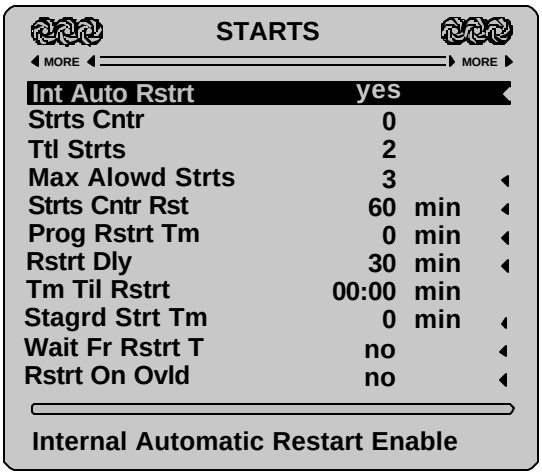
Note, if the controller does not allow the user to "edit" any reading even though the edit arrowhead is displayed, it is possible that system security has been enabled and the user must first enter a valid password. Read the SYSTEM SECURITY section to learn about working with security levels. “Read-only” parameters or menu selections do not display the small triangular graphic symbol at the right side of the display line.
The screen at left shows Present Value as “read-only”, three editable parameters and two menu selections.

BASIC OPERATION



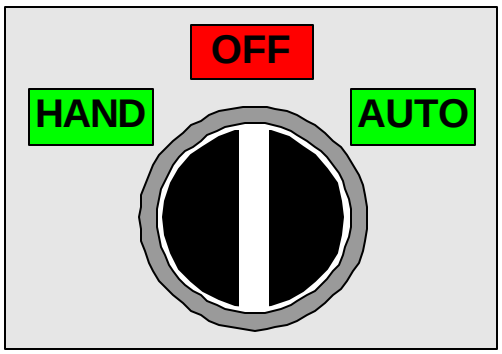
START / STOP DISPLAY UNIT SWITCHES

The Electrospeed GCS's display unit keypad provides a discrete push-button switch for START and STOP. To start a motor manually, press the START button. To shutdown a running motor, or to clear a lockout condition, press the STOP button on the display unit.



HAND/AUTO MODE SELECTION

The HAND or AUTO operational mode is determined by the status of the INTERNAL AUTO RESTARTS (Int Auto Rstrt) parameter that is found on the STARTS screen of the BASIC DRIVE SETUP menus. When this parameter is set to "YES", the AUTOMATIC RESTART mode is selected. The controller will automatically start the motor after the restart time delay has expired, if there are no active alarms. The motor can be started at any time by pressing the start button unless the WAIT FOR RESTART TIMER (Wait Fr Rstrt T) setpoint is enabled. In this case, the motor will not start until the restart time delay has expired. In no case will a start be allowed if any alarms are active and do not have an associated start bypass time delay. If a shutdown has occurred that causes a lockout condition, the lockout must be cleared before the controller will allow another start attempt. A lockout condition can be cleared by pressing the STOP button switch on the display keypad. When the INTERNAL AUTO RESTARTS (Int Auto Rstrt) parameter is set to "NO", the HAND mode of operation is selected. When the HAND mode is selected, the motor can only be started manually by pressing the start button.

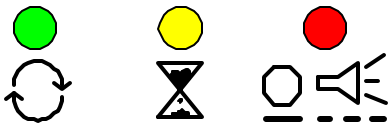


HAND/OFF/AUTO AND START PANEL MOUNTED SWITCHES

The controller's mode of operation can also be determined by the status of optional, externally mounted Hand/Off/Auto (HOA) mode and START switches. A running motor can be shutdown or a lockout condition can be cleared manually by changing the position of the HOA switch to the OFF position and then back to the desired mode of operation, Hand or Auto. If external, panel mounted switches are used, be sure to enable them by setting the EXTERNAL HOA parameter to "YES". This parameter is found in a sub-menu of the SCADA & SECURITY & SYSTEM menu selection.

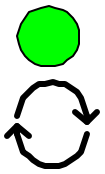
AUXILIARY RESTART PARAMETERS

When the GCS controller has been configured to restart automatically, it normally uses two global parameters, Maximum Allowed Restarts and Restart Time Delay, to determine how many starts are allowed and how long to wait before attempting the start. However, under some circumstances it can be desirable to configure those restart parameters differently based upon what the cause of the shutdown was. Every shutdown alarm in the GCS controller has an associated set of restart parameters connected with it. When these are enabled, and the controller shuts down because of that specific condition, it will use those parameters to control the restart attempt. If those parameters are not enabled, but automatic restarts are allowed, the controller will use the global restart time delay and start attempts.



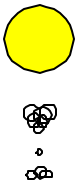
GREEN, AMBER AND RED DISPLAY LEDS

The Electrospeed GCS display unit has red, amber and green LEDs (Light Emitting Diodes) built into it. These lights function slightly differently than any external, optional panel lights do and are not affected by the panel light mode selection. These lights can be used in combinations so that the combined states indicate the following.

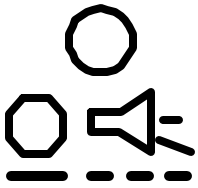


Green light on steady: The motor is running with no pending shutdowns or alarms.

Green light on with amber flashing: The motor is running, but an alarm is active and its associated time delay is counting down to expire. If the alarm persists past the associated time delay, the motor will shutdown.



Amber light on alone: The motor is stopped, but there are no active alarms and the motor will automatically restart when the restart time delay has expired. If the parameter, "Wait for Restart Timer" is disabled, the motor can be started at any time by pressing the start button.



Red light on steady: The motor is stopped because of a manual or operator stop or a central computer shutdown command.

Red light on flashing: The motor is stopped because of one of the enabled alarms. Restart will not occur without operator intervention

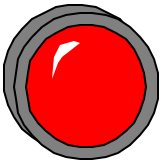
Red light on flashing with Amber: The motor is stopped because of one of the enabled alarms. Restart will occur when restart time delay has expired.

CONNECTING EXTERNAL RED, AMBER AND GREEN PANEL LIGHTS

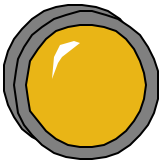
Optional, external panel lights can be connected to the three digital outputs provided onboard. The three digital outputs corresponding to the RED, AMBER and GREEN lights are located on the system control board's (SCB) connector labeled J24. Digital output 1 corresponds to the GREEN light, Digital output 2, the AMBER light and Digital output 3, the RED light. All three outputs are "dry contact" , Normally Open (N.O.) relay contacts rated for 10 Amps @ 250 Volts.

PANEL LIGHT DISPLAY MODE

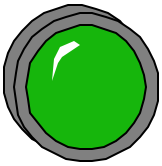
The red light indicates that the motor is stopped and that no automatic restart will occur. This may be because:



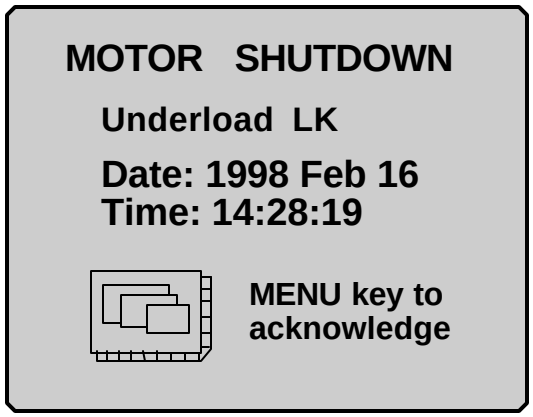
1: An alarm is still active, or
2: The last shutdown caused a lockout condition, or
3: The Hand/Off/Auto switch is in the OFF or Hand position, or
4: The controller has received a valid shutdown command from a central computer .

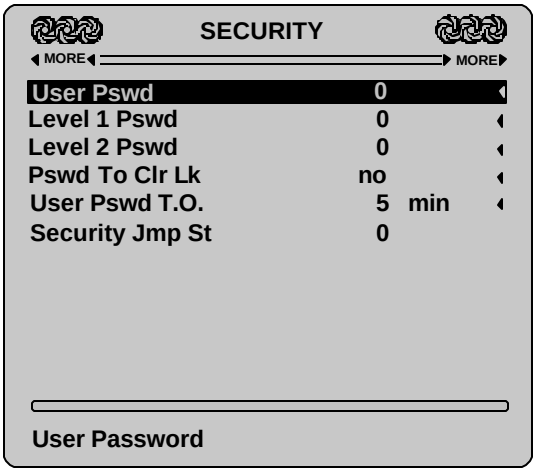


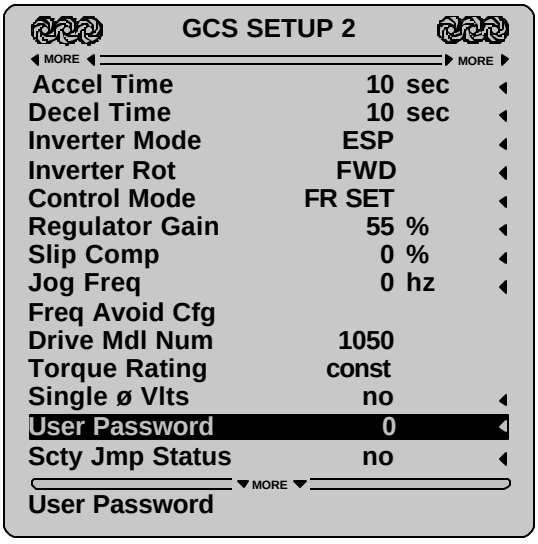
The amber light indicates that the motor is stopped, but all alarms are clear and the controller is counting down the RESTART TIME DELAY. When this delay has expired the Electrospeed GCS will automatically restart.



The green panel light indicates that the motor is running.







ALARM AND SHUTDOWN INDICATION

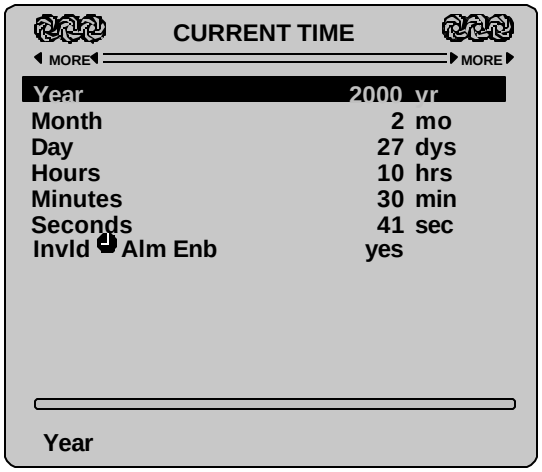
The Electrospeed GCS always enunciates live alarm and shutdown information on the "STATUS" screen of the display unit. The controller will also display an alarm alert screen after any shutdown occurs. This “pop-up” alert screen is displayed on top of all other screens and shows the time and cause of the motor shutdown. Press the MENU or ENTER button to acknowledge and clear this screen and return to the previously displayed screen.

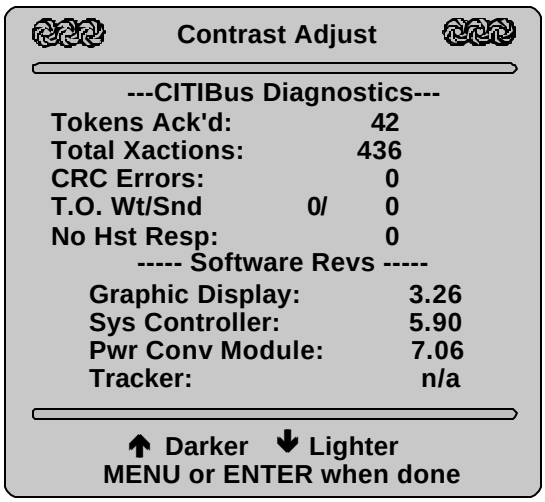
LOCKOUT CONDITION

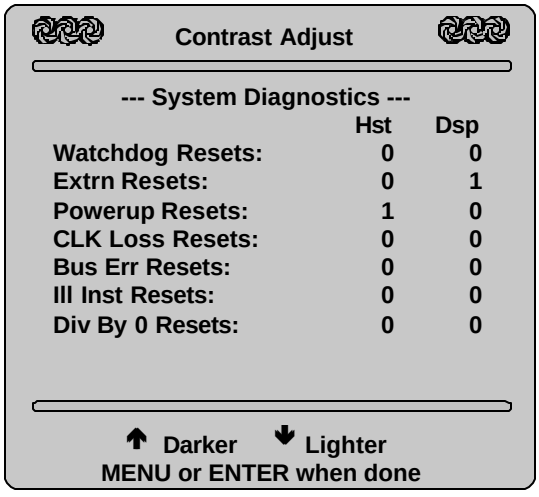
Any of the protective shutdown alarms can be configured to cause a lockout condition and this situation is indicated by “LK” or “LKout” accompanying the cause of shutdown. If such a lockout condition has occurred, no starts of any kind, manual or automatic, will be allowed until the lockout has been cleared. A lockout can be cleared by pressing the STOP keypad switch on the Display unit or changing the position of the HAND/OFF/AUTO Mode switch, if installed, to OFF and back to HAND or AUTO.

SYSTEM SECURITY

The Electrospeed GCS has the capability of administering security protection to guard against unauthorized setpoint editing. The security is initiated by entering a code number or password into the Level 1 and/or 2 setpoint. If a password code number is entered into either security level setpoint, then an operator must enter the same password into the User Password variable before any changes to setpoints or readings will be allowed. Without any security level achieved, the operator may view most display screens but will be unable to edit or change them. Level one of security will grant access to the most commonly used or changed setpoints, such as modifying alarm thresholds of protection setpoints. Level 2 security grants access to most of the other setpoints. The controller is shipped from the factory with all security protection disabled, so if an operator is unable to change setpoints in the field, a security code will have been entered in the field by local personnel. These local personnel should then be contacted to learn the security code required. The SECURITY input screen can found under the SCADA & SYSTEM & SECURITY section of the main display screen. The user password is found under the GCS setup 2 screen.







SYSTEM TIME CLOCK

The Electrospeed GCS uses a battery backed real time clock circuit for time keeping functions. All events and shutdowns recorded are time stamped with the date and time of occurrence. A battery is supplied with the system that will keep the clock up to date in the event of a power failure or shutdown. The system clock can be set to the current date and time by entering the desired data into the SET TIME menu screen found as a sub-menu of the SCADA & SECURITY & SYSTEM menu. This time keeping device is year 2000 compliant.

CONTRAST ADJUSTMENT

The GCS display unit uses a temperature sensing circuit to automatically adjust the contrast of the LCD display screen. If manual adjustment of the contrast level becomes necessary, use this screen. To activate this adjustment screen, press both the LEFT and RIGHT arrow keys simultaneously, hold briefly, then release both keys. A screen similar to the one at left will be displayed. At this point, use the UP and DOWN arrow keys to adjust the contrast higher or lower as required. The CITIBus diagnostics information is displayed as the upper half of this screen. CITIBus is the trademark name of the hardware/software connection and communication between different GCS modules connected together in this configuration. This information can be used to diagnose problems if they arise.

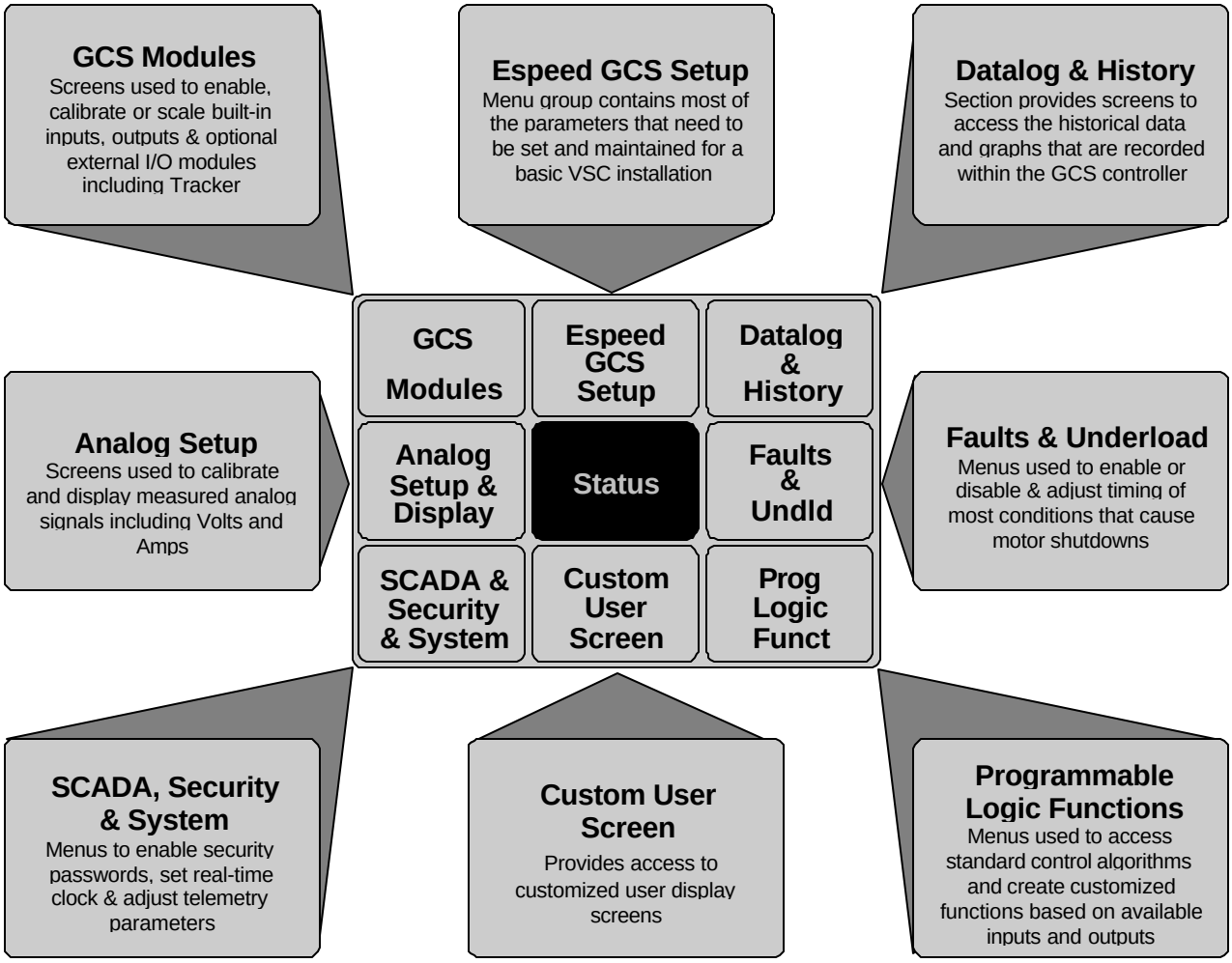
SOFTWARE REVS

This screen also displays the software revision levels loaded into this unit. As illustrated, the GCS unit displays the label for the Tracker software revision number. If a Tracker unit were installed, its software revision number would be shown. Since it is not installed within this configuration, it is shown as n/a (not applicable). Contact Centrilift personnel for software upgrades if required.
When the LEFT or RIGHT arrow keys are pressed while in the first contrast adjust screen, a second screen of information will be displayed. This screen, System Diagnostics displays the causes or types of any resets that the microprocessors have received. The HST column represents the system controller host (In this case, Hst is an Electrospeed GCS), while the Dsp column represents the graphic display unit.
Once adjustments are complete, press the ENTER or MENU key to return to the GCS menu system.

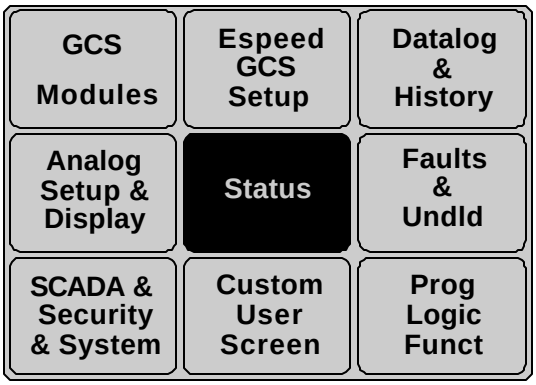
THE GCS MENUS

The following section will list and provide explanations of all the menus and parameters that are available to the user. The order in which the parameters are listed is based on starting with the MAIN MENU screen of the display, as shown below, then proceeding clockwise from ESPEED GCS SETUP, around the perimeter. Some of the display screens are longer than will fit unto the 11 lines of text available on one screen. For clarity within this manual, most of those screens will be illustrated longer than normal to show all of the parameters available. To locate information pertaining to any specific parameter, use the index at the end of this manual to locate a keyword, then view the information on the page(s) indicated.

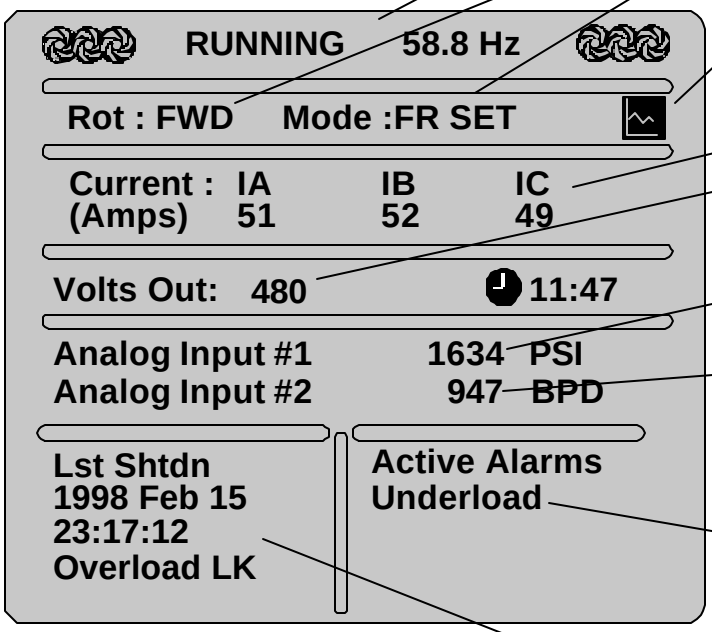
OVERVIEW OF ELECTROSPEED GCS MENU STRUCTURE



STATUS SCREEN



The status screen is the primary operator's display. From here, the operator can view most of the parameters needed when determining the run status of the controller. As illustrated below, the screen contains the following information



The motor is running at 58.8 Hz

Output phase rotation=Forward
Speed Control = Frequency Setpoint
The Amp Chart graph can be reached by pressing the ENTER
If unit is locked out, the padlock icon, , is also displayed here

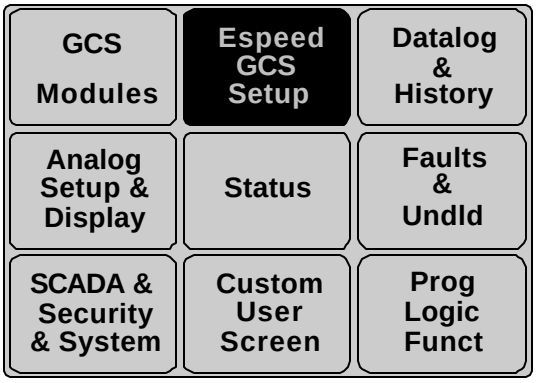
The output currents are 51, 52 & 49 amps, output voltage is 480

Analog input #1 measures bottom hole pressure
Analog input #2, barrels per day of fluid produced

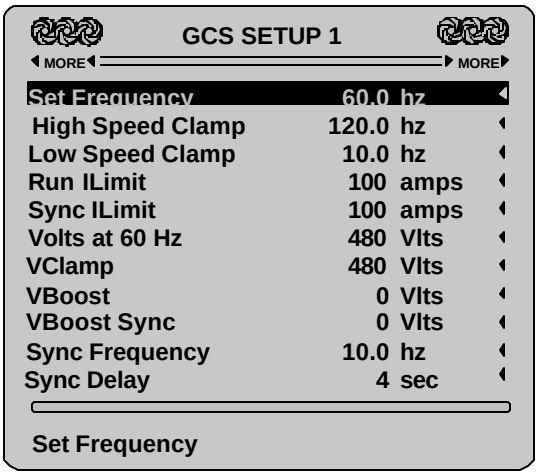
The controller is detecting an Underload alarm condition and waiting for the time delay before it shuts down the motor.

The most recent shutdown caused by an Overload Lockout condition on February 15, 1998 at 11:17:12 PM local time

ESPEED GCS SETUP



When the cursor is moved to the top center position of the Main Menu screen, and the ENTER key is pressed, the first of three GCS DRIVE SETUP screens displayed. These screens gather together most of the parameters needed to start-up and run the Electrospeed GCS drive. To display another screen, press the left or right arrow key. To edit any parameter, use the arrow keys to move the cursor bar over any menu item as shown at left below and press the ENTER key. The GCS will enter the “edit” mode and allow changes to the value of that parameter. The three screens available within this group are GCS SETUP 1, GCS SETUP 2 and STARTS. Each is reviewed in the following.

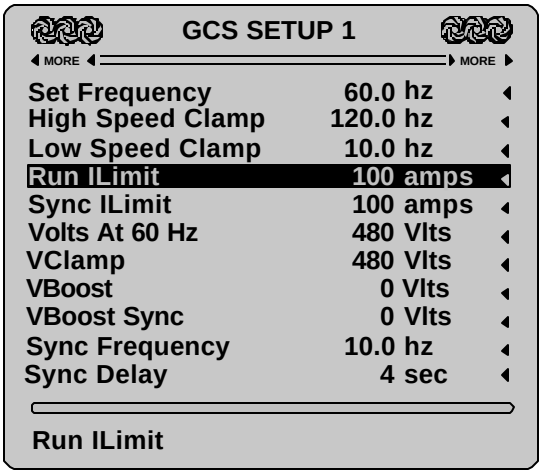


GCS SETUP 1

Set Frequency Controls the output frequency of the variable speed drive while operating in Frequency Setpoint Control mode. The output frequency is adjustable in 0.1 Hz. increments between the Low Speed Clamp and High Speed Clamp setpoints. Operating speed is also limited by the current limit setpoint, Run ILimit.

High Speed Clamp Sets the maximum frequency that the Electrospeed GCS is permitted to operate at and is programmable between 10 and 120 Hz. The maximum operating frequency should not be allowed to exceed the maximum operating speed for the equipment operated, as recommended by the manufacturer. Operating rotating equipment above maximum rated speeds, may result in damage to equipment and injury to personnel.

Low Speed Clamp Low Speed Clamp sets the minimum allowed operating frequency, and is programmable from 10 to 110 Hertz. For submersible motors, the Low Speed Clamp setpoint should not be set below the speed that provides adequate fluid flow rate past the motor for proper cooling. The flow of cooling air for conventional motors also decreases with speed creating potential cooling problems, especially in constant torque applications where high input currents are needed at low speeds. The minimum operating speed should be based on the motor manufacturer's recommendations.

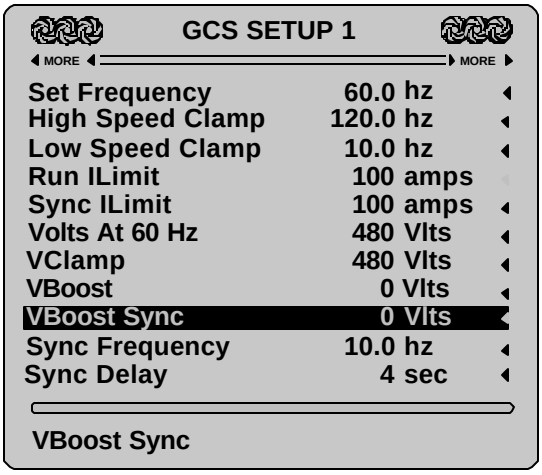


Run ILimit Running Current Limit, controls the maximum output current that the drive will deliver to the motor or load during normal operation. Run ILimit is adjustable from 0 to 150% of the controller's output current rating. Run ILimit is not effective during Sync Delay. If the controller is operating in Run ILimit, the output frequency will change within the High Speed Clamp and Low Speed Clamp range to maintain the output current at the Run ILimit value.
Run ILimit is frequently used in submersible pump applications to limit the motor input current to its nameplate rating. When gas is ingested into the pump, the load will decrease, allowing for higher frequency operation at the Run ILimit current. The higher speeds will help force the gas on through the pump, at which time the load will increase, and the frequency will drop.

Sync ILimit Synchronization Time Delay Current Limit sets the maximum output current produced during Sync Delay, and is adjustable from 0 to 150% of the controller's output current rating. A good initial setting for Sync ILimit would be 150% of motor nameplate current. If an output transformer is used, as with submersible pumps, set this parameter to 150% of the motor current multiplied by the transformer ratio (output voltage divided by input voltage).

Volts at 60 Hz Volts at 60 Hz sets the ratio of voltage to frequency. This setting determines the voltage produced by the drive when the output frequency reaches 60 Hz. The typical setting for surface motors would be the nameplate voltage for 60 Hz. If the motor nameplate voltage is for 50 Hz. multiply by 1.2 to arrive at the proper voltage for 60 Hz. operation. When an output transformer is used, as with a submersible motor, divide the nameplate voltage by the transformer ratio (input voltage / output voltage). If 50 Hz. rating, multiply by 1.2 as before. In some cases the "Volts at 60 Hz" parameter will exceed the 480 volt rating of the controller, however, this only sets the voltage to frequency ratio, and the drive output will not exceed its ratings. Motors exhibit the characteristic of having a minimum current point, established by voltage and load. The Volts at 60 Hz parameter can be adjusted while the system is operating to determine the minimum current point. Increase or decrease the Volts At 60Hz setpoint a few volts at a time, while monitoring the current and thus determine the minimum current point.

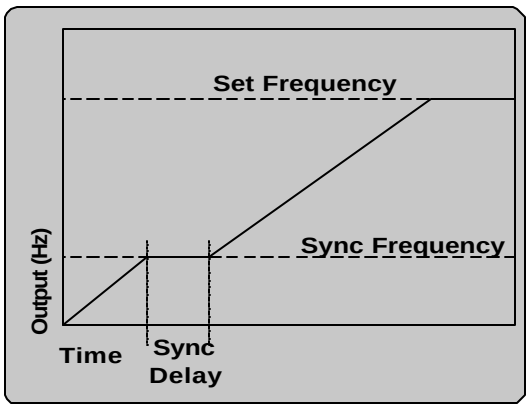
VClamp Voltage Clamp sets the maximum output voltage that will be produced by the drive at any frequency and determines when the drive begins constant horsepower operation. VClamp is adjustable from 100 to 550 VAC. Typical settings would be 480VAC for 460/480VAC input or 400 VAC for 380/400. The maximum



obtainable output voltage will be approximately 5% higher than the input voltage, but cannot exceed 550 VAC.

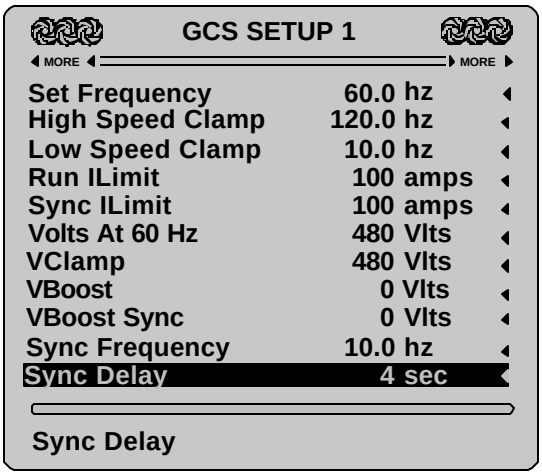
VBoost Voltage Boost controls the amount of offset voltage added to the zero speed voltage level which is otherwise zero volts. At low frequencies it is sometimes desirable to increase the output voltage above the normal base voltage since the resistive portion of the motor impedance becomes more significant when compared to the reactive portion. This can limit the motor excitation current, reducing available torque at low speeds. By adding VBoost, low speed performance can be improved and it can also compensate for the effect of output cable and/or transformer voltage drop, which will also be more pronounced at low frequencies. The volts-per-hertz ratio is then automatically adjusted to decrease the effect of VBoost linearly with speed, such that at maximum speed the effect is zero. VBoost is not active during Sync Delay. Initial setup should typically be done without any VBoost, and should then be increased if and when necessary. Generally VBoost is not used with variable torque loads, since the motor load decreases so dramatically with speed. The effective decrease in voltage that is experienced may even improve the efficiency of the under-loaded motor. Constant torque loads, however, require full torque even at low speeds, making the use of VBoost necessary in those applications. One way to determine the proper amount of voltage boost in a constant torque application would be to operate the controller at minimum speed, and adjust VBoost to obtain minimum current, similar to the technique described in the Volts at 60 Hz section.

VBoost Sync Voltage Boost During Synchronization Delay controls the amount of voltage increase added to the base voltage at the starting frequency. VBoost Sync performs the same basic function as VBoost, but is present only during starting, to properly compensate for the higher voltage drop associated with starting currents. VBoost Sync should be set to zero for the initial start-up, and increased only if difficulties in starting are encountered. The output current should be monitored during the initial start attempts to determine the maximum output current delivered in the event the start is unsuccessful. The output current not reaching the ILimit Sync value is an indication that increasing VBoost Sync could increase output current. VBoost Sync is adjustable from 0 to 200 VAC

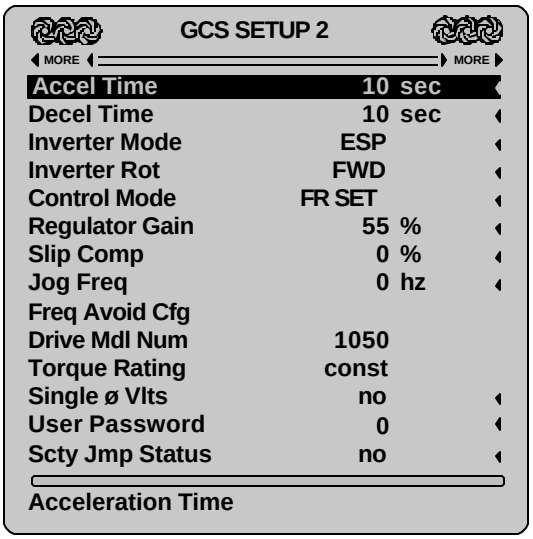


Sync Frequency Synchronization Frequency sets the output frequency in Hz, that the drive will use to start the motor. As illustrated at left, when the system is started, the drive will ramp up to the set Sync Frequency. The output will be held at the Sync Frequency for a period of

time referred to as Sync Delay. The Sync Delay time allows the motor to accelerate to the starting frequency. At the end of the Sync Delay time, the drive will accelerate the motor to the preset operating frequency. The Sync Frequency should be set as low as practical for the application. Typical settings would be 10 to 12 Hertz for submersible motors and 3 to 5 Hz for surface motors. The available motor starting torque is directly proportional to the square of the starting current, and inversely proportional to the starting frequency. This shows the first criteria for successful starting is to be able to deliver the maximum current available to the motor, and the second criteria is to start at the lowest possible frequency.



Sync Delay Synchronization Time Delay sets the amount of time in seconds that the drive will allow for the motor to accelerate to the starting speed established by Sync Frequency. Sync Delay is adjustable from 0 to 9999 seconds. Typical settings for submersible installations would be 2 to 5 seconds. Surface motors require more time due to higher inertia and are typically set at 5 to 10 seconds. At the end of Sync Delay the controller will accelerate the motor at the Accel Time rate, or will follow the motors' acceleration limited by Run ILimit, to the preset frequency. If Sync Delay is too short, the motor may not start. If this happens, the controller will typically shut down in overload. As additional protection, the Electrospeed GCS will shut down on a Low Speed trip if it is operating in Run ILimit, below Low Speed Clamp, and the output frequency is not increasing. This provides a positive means for detecting a stalled motor.

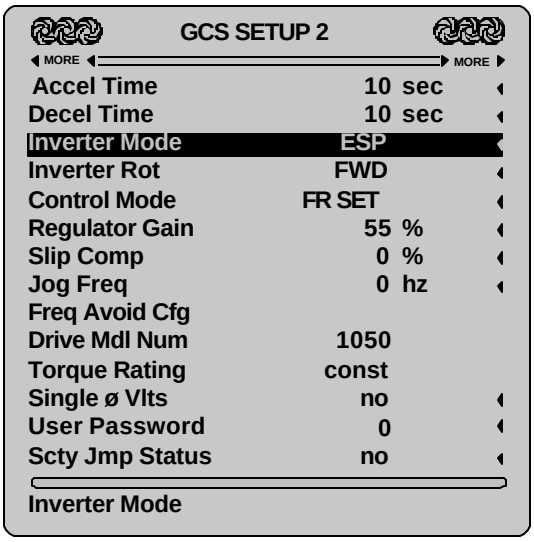


GCS SETUP 2

The GCS SETUP 2 menu is accessed from the GCS SETUP 1 screen by pressing the right arrow key once.

Accel Time Sets the time required for the controller to increase its output frequency by 60Hz and is adjustable from 2 to 200 seconds. Acceleration does not commence until the sync delay has expired. To determine actual rate (Hz./sec), divide 60 by the set time in seconds. The motor acceleration will be limited by this setting if the controller is allowed to provide sufficient current to maintain the rate, otherwise the acceleration rate will be limited by available current (ILimit). When operating in the set point control mode, the Accel Time should be set to the minimum value, 2 seconds, to allow the response of the controller to be regulated by the set point control algorithm.

Decel Time Deceleration Time sets the time required for the controller to reduce its output frequency by 60Hz and is adjustable from 2 to 200 seconds. To determine the



actual rate (Hz./sec), divide 60 by the set time in seconds. If the controller is operating a high inertia load, the deceleration rate may be limited by the inertia of the motor and load. Under these conditions, the deceleration rate will follow the coast time of the motor. When operating in the set point control mode, the Decel Time should be set to the minimum value, 2 seconds, to allow the response of the controller to be regulated by the set point control algorithm.

Inverter Mode Sets the type of output wave form that will be produced by the GCS drive. There are three possible modes:

> **ESP** The ESP mode produces a pseudo-sinusoidal wave form that has six voltage transitions (6-step output) in the recreated output signal.
>
> **HYB** Hybrid PWM creates a variable voltage, pulse width modulated output wave form that can be useful in some applications to reduce the current harmonics to the motor. Hybrid PWM can also reduce peak cable voltage stresses under some conditions.
>
> **PWM** PWM mode is a standard, full bus voltage, pulse width modulated wave form. This output has its best applications in surface motors where a step-up transformer is not used and the power cable from the drive to the motor is relatively short.

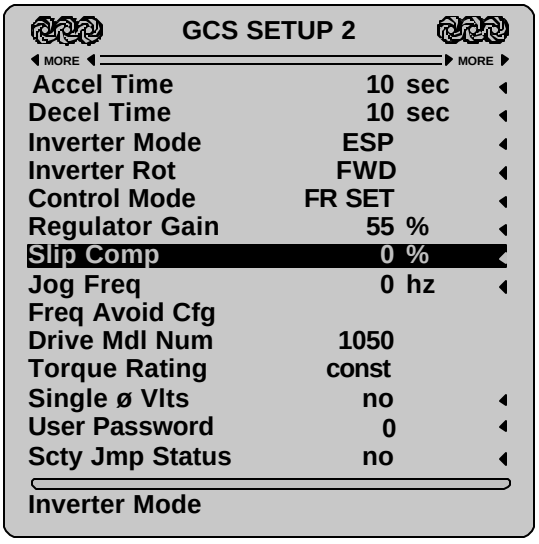
Inverter Rotation Controls the direction of output phase rotation of the drive. The choices are FWD (forward) and REV (reverse). This rotation is defined by the phase rotation sequence of the three output voltages or currents, ABC (forward) or CBA (reverse).

Control Mode Control Mode selects which type of control algorithm will govern the output of the drive. There are three available modes:

> **FR SET** Frequency Setpoint mode causes the Electrospeed GCS to attempt to operate at the user programmed Set Frequency, accessed in the GCS Setup 1 menu group. Note that several factors may affect the controller's ability to achieve this frequency including, ILimit, High Speed Clamp and Low Speed Clamp.
>
> **AN FOL** In Analog Follower mode, the controller will attempt to vary its output frequency between the Low Speed Clamp and High Speed Clamp in

proportion to 0-100% of the analog input signal selected. The parameters affecting this control method are found in the Prog Logic Funct menu group.

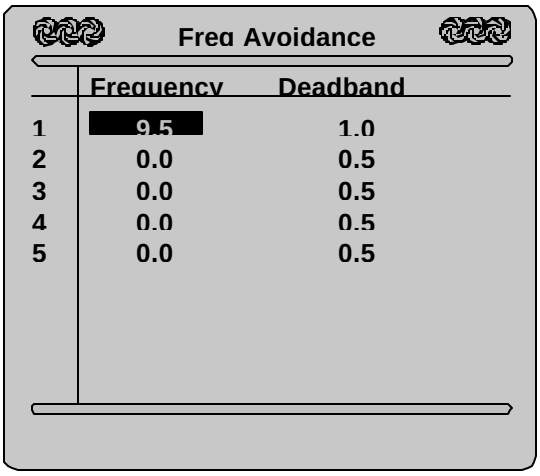
PID In PID mode, the controller will attempt to vary its output frequency in order to maintain a given analog input signal. The parameters affecting this closed loop control algorithm are found in the Prog Logic Funct menu group.



Regulator Gain Controls the response of the bus voltage control loop to changes in input voltage, load and output frequency. Regulator Gain is adjustable from 0 to 100%, with a factory default setting of 55%. Increasing regulator gain speeds up the regulator response and can be used to compensate for power system instabilities. When operating no-load, the gain should be set to 50% or higher to obtain a stable output voltage.

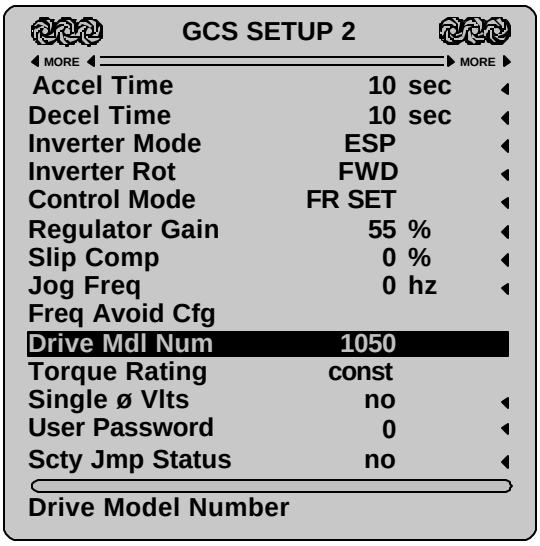
Slip Comp Slip compensation provides output speed correction proportional to output current that increases inverter frequency and voltage output to offset induction motor slip with load. Slip compensation should be set to the full load slip (in percent) value for the motor and is adjustable from 0 to 7.0 % in 0.1% increments. It is primarily used when precise speed control of the motor is required under widely varying load conditions.

Jog Freq Jog Frequency is a frequency set point that is activated by the Jog input. While the Jog input is active, the drive will process a normal starting sequence and accelerate the output frequency up to the jog frequency set point. The controller will operate at this jog frequency as long as the jog input is active. When the Jog input is de-activated, the drive will decelerate to a controlled stop.



Freq Avoid Cfg Frequency Avoidance Configuration provides access to a user programmable table of five output frequencies the drive is not permitted to operate at. Press the ENTER button while highlighting this menu item to access the table of values.

Freq Avoidance This table allows the user to specify five individual frequencies that the drive will not produce. Each frequency entered has an associated deadband value. This deadband value instructs the drive as to how close to the disallowed output frequency it can run. As illustrated at left, the first frequency to avoid has been set to 9.5 hertz with a deadband of 1.0 hertz. This means that the Electrospeed GCS will not allow steady state operation within the range of 8.5 to 10.5 Hz. The drive will produce those frequencies only while it is ramping its output from one side of the prohibited range to the other



side. These settings can be used to prevent unwanted vibrations that may be generated as a result of equipment resonance at specific frequencies.

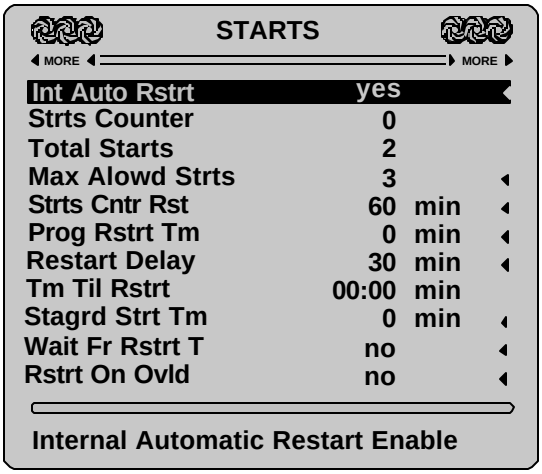
Drive Mdl Num Drive Model Number displays the model number of this drive. The base model number for each Electrospeed GCS is stored in memory on the System Control Board, along with upper and lower limits for parameters affected by the ratings of the controller. Every time the drive is powered on, it will retrieve the model number and associated limits from memory. This model number should agree with the model number stamped onto the nameplate riveted onto the outside of the controller enclosure.

Torque Rating Torque Rating indicates the type of output torque that the drive will produce, either CT (constant) or VT (variable). The basic Electrospeed GCS controller models are set up for variable torque loads. Contact Centrilift service personnel to convert to a constant torque setting. This will de-rate the output current and KVA ratings by 20%, but the overload and start currents will remain the same.

Single ø Vlts This parameter configures the Electrospeed drive to operate from a single phase of input power as opposed to the usual three phase source. The input power must be connected to the A and B input terminals. The three phase power output is de-rated to reflect the lower input power available. This configuration can be very useful to drive small three phase motors when only single phase power is present.

User Password This parameter permits entry of the operator's password. When system security has been enabled, the operator must enter the correct password in this location before being allowed to modify any other set points or parameters. Read the SYSTEM SECURITY section for more information about working with security passwords.

Scty Jmp Status Security Jumper Status indicates whether the service technician has installed the service access jumper. Installing this jumper permits access to the drive setup regardless of the password security settings.



STARTS

The GCS DRIVE STARTS menu is accessed from the GCS SETUP 1 or 2 screen by pressing the right or left arrow key until the screen shown at left is displayed.

Int Auto Rstrt This parameter, Internal Auto Restart, controls whether the drive will automatically restart the motor after it has shutdown and is not locked out. This parameter is used in the absence of an externally mounted HAND-OFF-AUTO (HOA) switch and is over-ridden by the position of the HOA switch when installed and enabled.

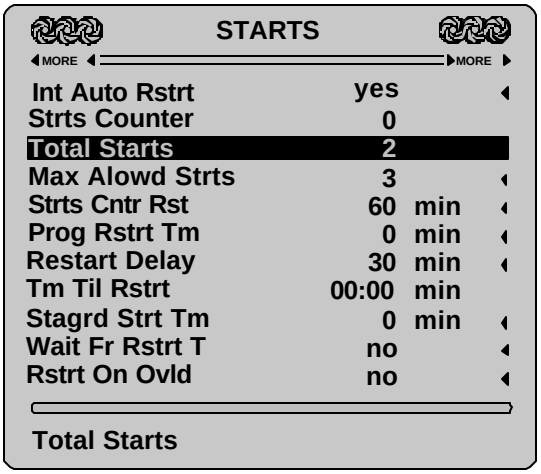
Strts Counter Starts Counter displays the number of times that the drive has automatically restarted the motor. This counter is used in conjunction with the following Maximum Allowed Starts and Starts Counter Reset Delay set points to limit and control the number of times the drive will restart the motor before assuming a lockout condition and preventing additional start attempts. A lockout condition can be cleared by pressing the STOP keypad switch or moving the HOA switch to OFF and back to AUTO or HAND.

Total Starts Total Starts records the number of times that the drive and motor have been started since the last reset to factory defaults command.

Max Alowd Strts Maximum Allowed Starts controls the number of automatic restarts that will be attempted by the drive before generating a lockout. If the drive attempts this many restarts and the motor does not run for a minimum of the time set in the Starts Counter Reset Delay parameter, the drive will then assume a lockout condition and prevent further restart attempts until the lockout is cleared. A lockout condition can be cleared by pressing the STOP keypad switch or moving the HOA switch to OFF and back to AUTO or HAND. This maximum starts parameter is used for all restart attempts, unless the Auxiliary Restart Parameters are enabled for that specific cause of shutdown.

Strts Cntr Rst Starts Counter Reset delay controls the length of time, in minutes, that the drive/motor must run before the controller resets the automatic starts counter and allows the full number of restart attempts to occur. When this time delay has expired and STARTS COUNTER is reset to zero, the drive can again attempt as many automatic restarts as allowed by the MAX ALOWD STRTS parameter. For example, if the motor has been started and has shutdown before the factory default delay of 60 minutes have elapsed, the controller will record 1 automatic start. If the motor is started again and shuts

down again before 60 minutes of running time, the controller will then show 2 automatic start attempts. If this situation is repeated once again, the controller will record the third automatic start attempt and generate a lockout condition. This "lockout" condition will prevent any subsequent start attempts until the lockout has been cleared. This time delay is also used by the following Progressive Restart Time parameter.



Prog Rstrt Tm Progressive Restart Time Delay provides a method of automatically increasing the amount of restart time delay that the drive waits for before restarting the motor. When this parameter is set to a non-zero value, that number of minutes will be added to the restart time delay used to postpone an automatic restart. In this situation, the drive will use the standard restart time delay for the first restart period and then add the progressive restart time delay to the second and subsequent restart attempts. To prevent an ever increasing restart time delay, the amount of progressive restart time added will revert to zero when the motor runtime has exceeded the previously discussed Starts Counter Reset delay.

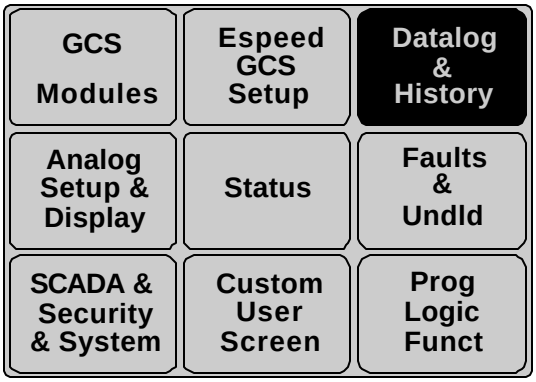
Restart Delay Restart Delay sets the amount of time in minutes the drive will wait after a shutdown, before attempting an automatic restart of the motor. If necessary, the motor can be started immediately by pressing the start keypad button or the panel mounted start switch if the panel is equipped with one. In all cases, the controller will attempt to restart the pump only if there are no active alarms and the Wait For Restart Timer setpoint is disabled. Restart delay can be automatically affected by the Progressive Restart Time delay set point previously discussed. If the Auxiliary Restart Parameters are enabled for the last cause of shutdown, the controller will use those specific settings for time delay and number of start attempts.

Tm Til Rstrt Time until Restart displays the number of minutes and seconds left before the drive will attempt to restart the motor. If this set point reads zero and the drive is not running, there could be active alarms, or restarting is prevented because the keypad STOP button was pressed, the external HOA mode switch is in HAND or OFF position, a telemetry shutdown control command is active or the Int Auto Rstrt parameter is set to “NO”.

Stagrd Strt Tm Staggered Start Time provides a means of setting a unique restart time delay for each controller. After a power failure, all controllers will wait for a time delay equal to the Restart Delay plus this staggered start time delay. Offsetting individual start times this way can help to prevent a voltage sag on the power system caused when many motors start at once.

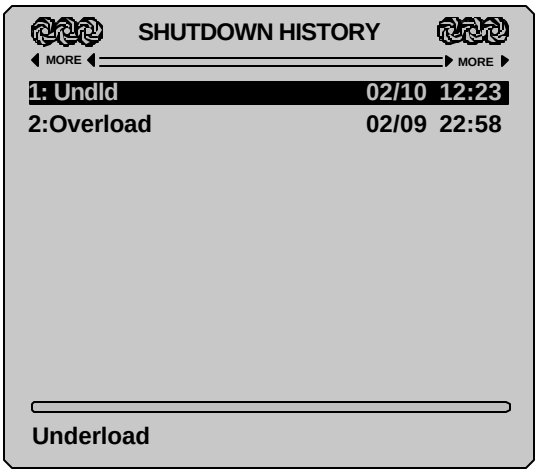
Wait Fr Rstrt T Wait for Restart Time Delay forces the drive to wait until the restart time delay expires before allowing any type of restart, either manual or automatic. To restart immediately in case of emergency, change this set point to “NO” and then start the drive. Be sure to set it back to “YES “ if restarts are to be prevented during the restart time delay. The controller will never attempt to restart the motor if there are active alarms.

Rstrt on Ovld Restart on Overload programs the Overload Auxiliary Restart Parameters (ARPs) to allow the controller one automatic motor restart attempt after an Overload shutdown. All Auxiliary Restart Parameters are accessible from each individual fault and alarm setup screen. Refer to the fault and alarm sections of this manual for further details



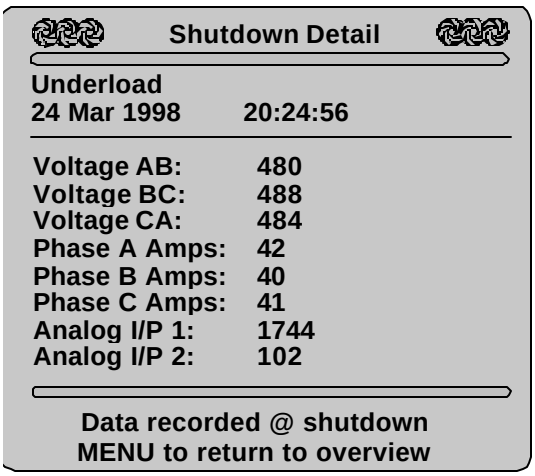
DATALOG & HISTORY

The DATALOG and HISTORY group of screens provides access to the recorded history stored within the Electrospeed GCS. This group of screens includes the SHUTDOWN HISTORY, EVENT RECORDS, RUN HISTORY, PC CARD DATA LOGGING AND GRAPHING.



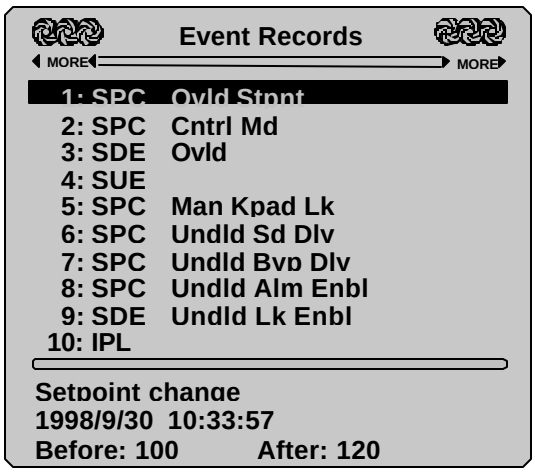
SHUTDOWN HISTORY

Shutdown History displays the cause, time and date of the last ninety-nine shutdowns. The screen holds eleven records at once. To view any other shutdown histories, press the down arrow key to move the cursor to the bottom of the screen and beyond, scrolling through all available records. The names of the causes of shutdown are often abbreviated, so if an explanation is required, the area at the bottom of the screen displays an expanded version of the cause.



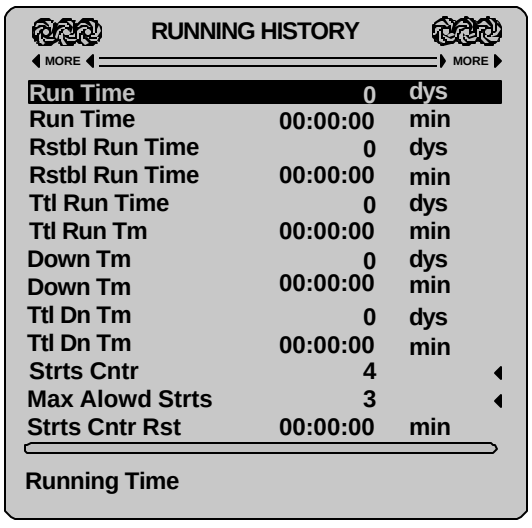
SHUTDOWN DETAIL

The Shutdown Detail screen is displayed when the ENTER key is pressed while the cursor highlights a shutdown history record. This record contains the value of the three current and voltage readings and the two analog input readings at the time this corresponding shutdown occurred. This data can be useful for diagnosing troublesome applications.



EVENT RECORDS

The EVENT RECORDS screen displays the 254 most recent events that have occurred since the controller has been installed and powered up. When the event buffer has been filled, the controller will begin to overwrite the oldest records with the latest event information. Each numbered entry in the list of events is followed by a three letter abbreviation indicating the type of event, which is in turn followed by the data base point description that caused or was affected by the event. At the bottom of the screen, three lines of information are displayed that show: the type of event (non-abbreviated), the time and date of occurrence and, in the case of a setpoint change, the before and after values of that setpoint. Use the UP / DOWN arrow keys to move the cursor up and down to highlight different events and view their information at the bottom of the screen. To quickly move the cursor from one end of the list to the other end of the list, press the ENTER key.



RUN HISTORY

The RUN HISTORY screen displays counters and timers that record various operating information about the installation. To access RUN HISTORY press the right arrow key from the EVENT RECORDS screen.

Run Time (days) This timer records the total number of 24 hour days that the motor has run since the last time it was started up.

Run Time This timer records the hours, minutes, & seconds (HMS) that the motor has run since the last start. When this timer reaches 24 hours, it will start again from zero, and Run Time (days) will be incremented by one day.

Rstbl Run Time (days) This user Resettable Run Timer records the number of 24 hour days that the motor has run since the last user reset.

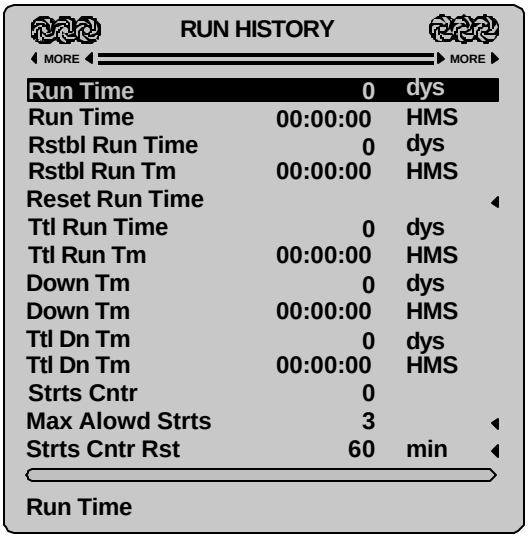
Rstbl Run Tm This user Resettable Run Timer records the number of hours, minutes, & seconds (HMS) the motor has run since the last user reset. When this timer reaches 24 hours, it will revert to zero and the Rstbl Run Time (days) timer will be incremented by one day.

Reset Run Time Use this display point to reset the Rstbl Run Time counters back to zero. Move the cursor until it highlights this point, then press the ENTER key. The two resettable counters will reset to zero, and , if the motor is running, immediately begin to accumulate run time.

Ttl Run Time Total Run Time (days) records the total number of days the motor has run since it was first installed and commissioned.

Ttl Run Time This timer records the hours, minutes, & seconds (HMS) that the motor has run since it was first installed and commissioned. When this timer reaches 24 hours, it will start again from zero, and Ttl Run Time (days) will be incremented by one day.

Down Tm Down Time (days) records the total number of days that the motor has been off since the last time it was shut down.



Down Tm Down Time counter records the hours, minutes, & seconds (HMS) that the motor has been off since the last time it was shutdown. When this timer reaches 24 hours, it will start again from zero, and Down Tm (days) will be incremented by one day.

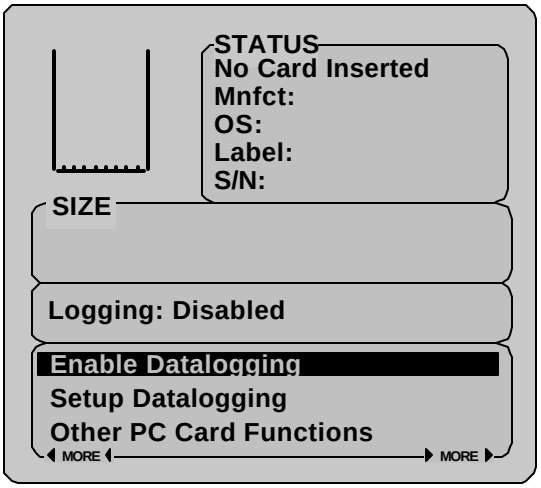
Ttl Dn Tm Total Down Time (days) records and accumulates the total number of days that the motor has been shut off since it was first commissioned and started.

Ttl Dn Tm The Total Down Time counter records and accumulates the hours, minutes, & seconds (HMS) that the motor has been off since it was first commissioned and started. When this timer reaches 24 hours, it will start again from zero, and Ttl Dn Tm (days) will be incremented by one day.

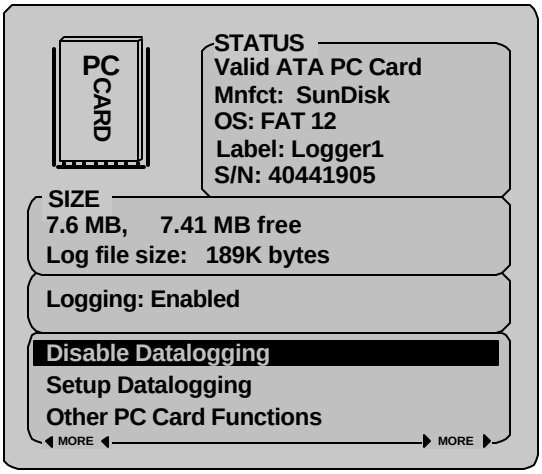
Strts Cntr Starts Counter displays the number of automatic restarts that have occurred, during which the motor did not run long enough to expire the Starts Counter Reset delay. If this starts counter reaches the value that is programmed into the Max Alowd Strts, the controller will enter a lockout state and will not allow further restart attempts until the lockout is cleared. This parameter is also accessible in the Electrospeed GCS SETUP menu group and is duplicated here for operator convenience only.

Strts Cntr Rst Starts Counter Reset delay controls the length of time, in minutes, that the motor must run before the automatic Starts Counter is reset to zero. When this time delay has expired and STARTS COUNTER is reset to zero, the controller can again attempt as many automatic restarts as allowed by the Max Alowd Strts parameter. This set point is also accessible in the ESPEED GCS SETUP menu group and is duplicated here for operator convenience only.

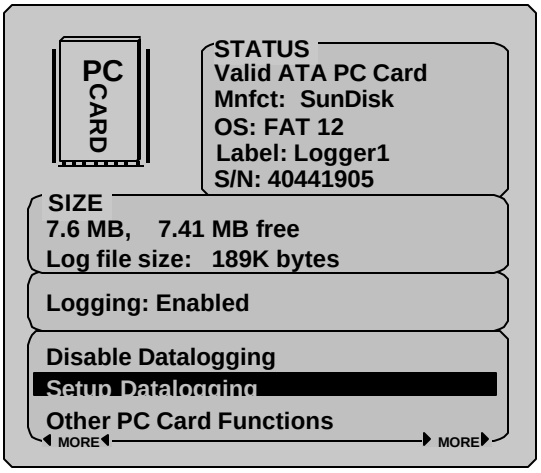
PC CARD DATALOGGING



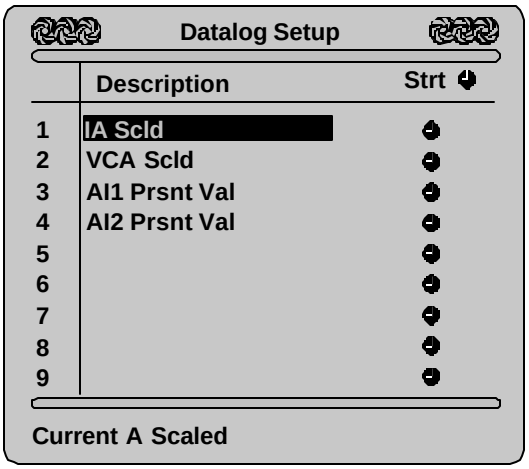
This screen provides access to the data logging functions provided with the GCS controller. The data recorded is stored onto a non-volatile memory card inserted into the provided socket on the GCS display unit. The PC memory cards are formatted and structured with a DOS file format. When plugged into the PC card slot of a personal computer, the card should appear as a disk drive and the logged data will appear as a normal “DOS” type of file upon that card. To use, view or manipulate the logged data, the user can open the file using MS Excel, MS Word or any other PC software that can import a “comma separated variable” or “CSV” file type. For more information regarding the use of the PC Card, consult Appendix K at the end of this manual. As can be seen in the next graphic below, the STATUS and SIZE portions of the screen are filled with appropriate information when a valid memory card is inserted.



Enable / Disable Datalogging Use this menu item to start or stop the data logging function. Move the cursor over this item and press the ENTER key to toggle between Enable and Disable. If this item is toggled to Enable Datalogging, the GCS controller will commence logging the data as configured within the next menu item, Setup Datalogging. Read the next section for instructions on configuring the data logging setup.



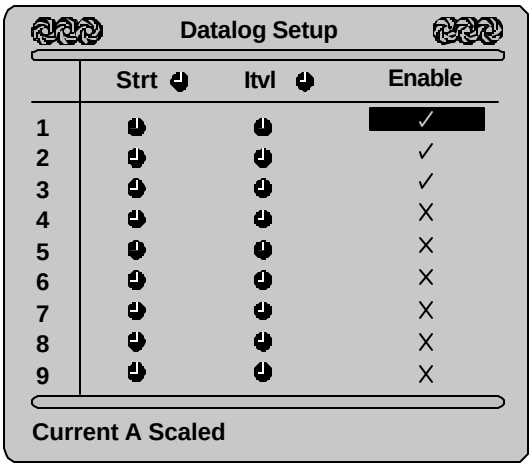
Setup Datalogging Move the cursor to this location and press ENTER. The GCS controller will then display a screen as illustrated below. This screen is used to configure the datalogging options. After the setup is completed, the configuration is stored within non-volatile memory and is retained even in the event of a power failure. In such a case, the user need not re-enter the setup, because the GCS will re-configure itself using this stored configuration.



DATALOG SETUP

This screen provides the user with the ability to configure the type and frequency of data to be logged. Up to twelve data variables can be logged at frequencies up to 1 Hz. Each of the twelve logged data variables requires the user to enter a point identification (PID), a start time and a logging time interval. Once the datalog setup is complete, press the MENU key to exit.

Description Move the cursor to highlight one of the rows (1 through 12) in this column and press ENTER. The cursor at that point will invert in color and the UP/DOWN arrow keys will scroll a list of loggable data points. Scroll the list until the desired point is displayed and press ENTER again. The selected data point is then selected for logging.

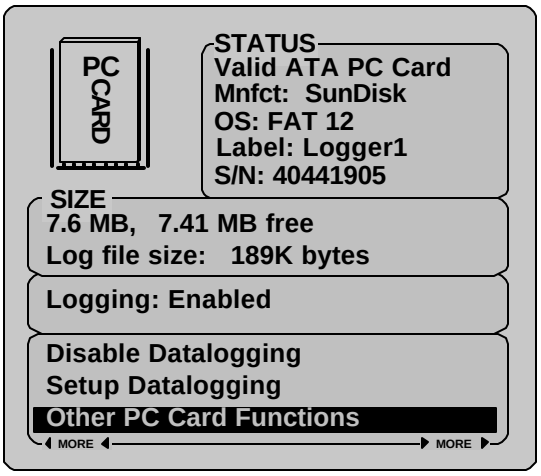


Strt **(Start Time)** The Start Time variable will delay the start of data logging for this point the number of seconds entered. For example, entering 45 will cause the first log sample to occur 45 seconds after being enabled. NOTE: This function not yet available

Itvl **(Interval Time)** Move the cursor to the Interval Time column and press ENTER to set the time delay between logged samples. This setpoint controls how often a data value is recorded for this data log point. The shortest interval possible is 1 second while the maximum time interval is 9000 seconds (2.5 hours).

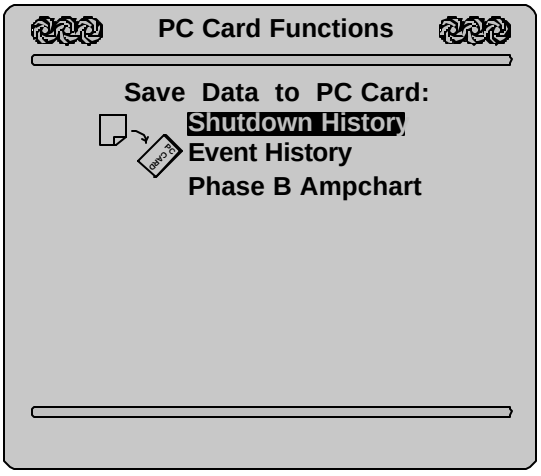
Enable This point controls whether the Electrospeed controller will record (log) the data associated with the description field. If this point displays a check mark, ✓, the data will be recorded, if it displays an X, the data will

not be logged. Move the cursor to this variable and press ENTER, then, press the UP or DOWN arrow keys to toggle the value between enabled and disabled.



Other PC Card Functions This menu selection provides access to any other PC Card Functions that are currently available. Move the cursor to this menu item, press ENTER and a menu similar to the next illustration will appear.

SAVE DATA TO PC CARD

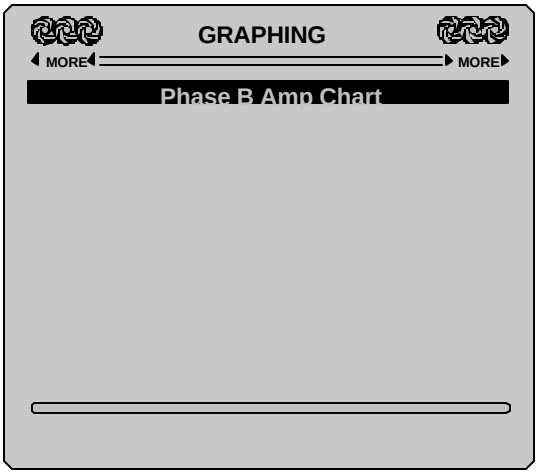


This group of functions allows the user to copy the internal history databases to the PC memory card. Most PCMCIA card slot enabled computers can read this card and the data contained therein. All the following data files are written to the PC card in a comma separated variable (*.csv) format. For more information regarding the use of the PC Card, consult Appendix K at the end of this manual.

Shutdown History This function will copy the internal shutdown history database from the Electrospeed GCS to the PC card.

Event History This function will copy the internal Event History database from the Electrospeed GCS to the PC card.

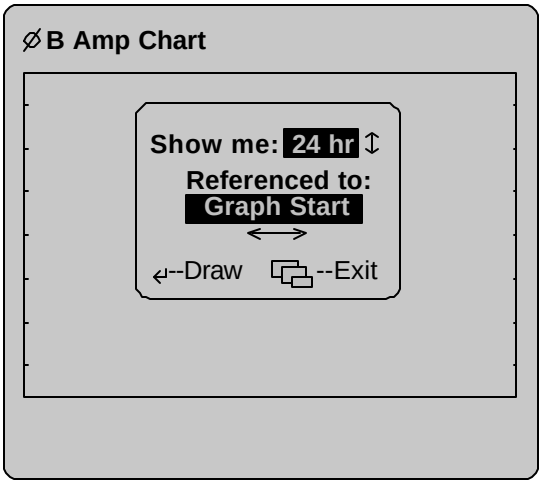
Phase B Ampchart This function will copy the internal Phase B Ampchart data from the Electrospeed GCS to the PC card.



GRAPHING

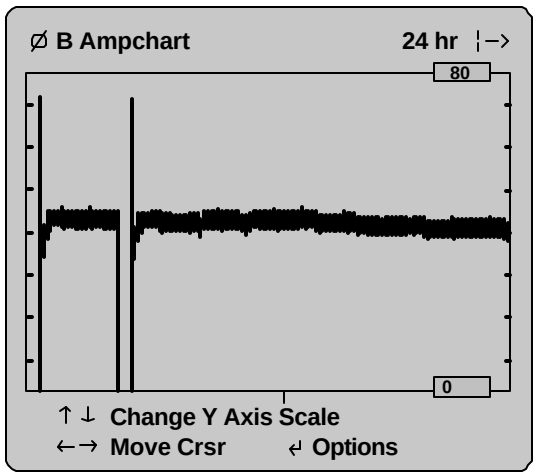
The GRAPHING group of screens gathers together any available graphing functions.

Phase B Amp Chart This time versus current graphing function serves the same purpose as the standard circular amp chart recorder commonly found in motor control applications. The Electrospeed GCS samples the phase B motor current and accumulates the readings over a four minute period. After this period, the maximum, minimum and average values are recorded for use in this graph. The controller records this data whenever the motor is running. When a full seven days of data have been captured, the amp chart function will begin to overwrite the oldest data with newly acquired values. In this way, the controller will always retain the data from the most recent seven-day run period. This data is also available to be downloaded to a portable computer for analysis and graphing in common application programs such as MS Excel and Lotus 123

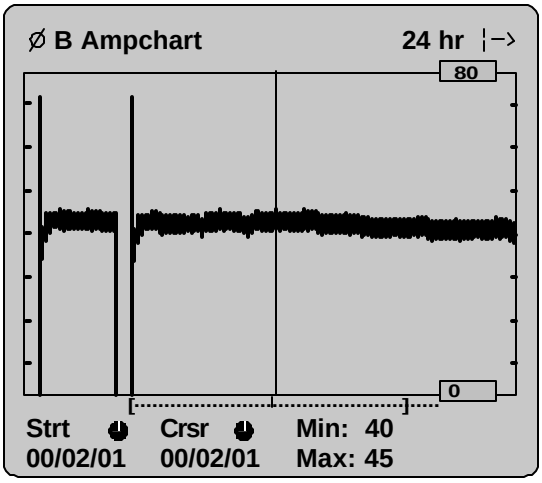


Ø B AMPCHART

This graph screen displays the recorded ampchart data described in the previous section. Use the UP/DOWN arrow keys to select the graph duration of 12, 24, 48 hours or 1 week. Use the LEFT/RIGHT arrow keys to select the graph's starting location reference. The Referenced To: Graph Start selection causes the graph's left side axis to be set to the beginning of the data and extend forward in time for the amount set by the UP/DOWN arrow keys. The Graph End selection sets the graph's right hand axis to the present time/date. The Referenced to Cursor selection creates a graph centered on the present cursor line position extending forward and backward in time for the duration selected in the Show me: selection. Once these options are set, press the ENTER key to display the graph. The next illustration below shows a 24-hour ampchart, referenced to the beginning of the data, February 1, 2000.



After the ENTER key is pressed, the Vortex will draw the graph and show the new key options at the bottom of the screen as shown at left. Whenever the graph is being displayed, pressing the UP/DOWN arrows will change the Y axis scale up or down. Pressing the LEFT/RIGHT arrows will move the cursor left or right on the screen. To display the Options (duration and reference) screen again, press the ENTER key. To display the time, date and current Minimum/Maximum values, press the LEFT or RIGHT arrow key. The graph screen will change to display the start time of the graph, the time of the present cursor position and the minimum and maximum recorded values at the cursor position. While the graph is being displayed, the Strt Time displayed represents the time/date at the left-hand axis, while the Crsr Time shows the time/date of the current cursor position. Both of these date displays will alternate between time and date at approximately one cycle per second.

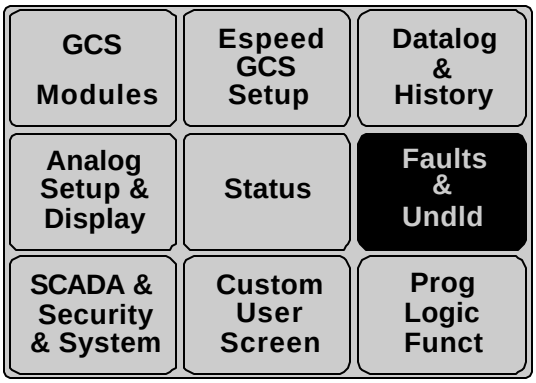


If desired, the data collected to create this graph can be transferred to a PC memory card inserted into the card slot on the graphic display unit. The command to copy the data to this card can be issued from the menu selections:

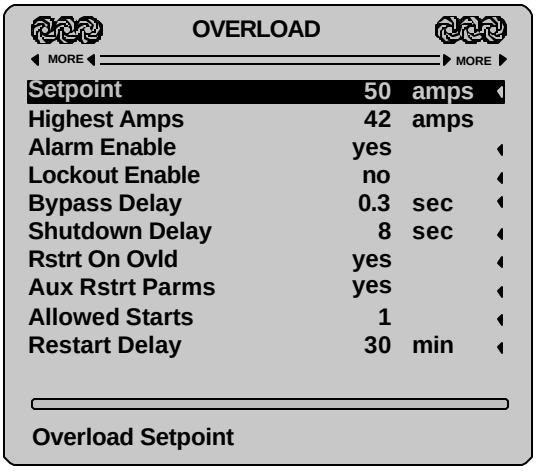
DATALOG / OTHER PC CARD FUNCTIONS / PHASE B AMPCHART

The data will be written to a PC card “DOS” type file named: AMPCHART.CSV

FAULTS & UNDLD



The FAULTS and UNDLD group of screens provides access to the motor protection features within the Electrospeed GCS. This menu group includes a set-up screen for each of the alarm conditions providing the user with complete control over the response of the motor controller to these occurrences. The first screen viewed after pressing ENTER at this Main Menu selection will usually be OVERLOAD.



OVERLOAD

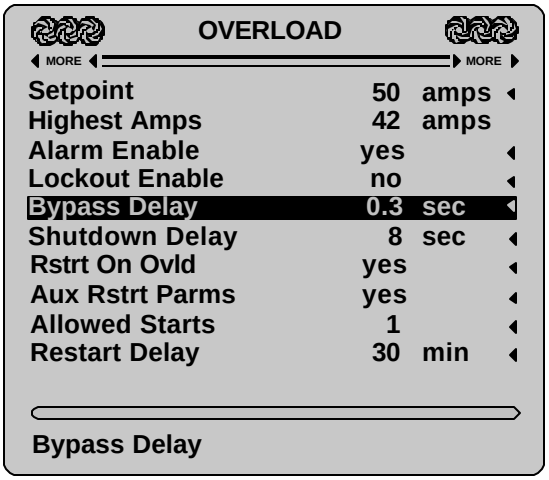
This screen gathers the parameters concerning overload protection into one group. Overload alarms protect the motor from excessive current draw.

Setpoint The overload setpoint determines the maximum output current that can be delivered to the motor without engaging the overload routine and subsequently causing a motor shutdown. The controller uses the highest of the three phase currents to calculate the magnitude of overload.. The typical setting for the overload setpoint is 0 to 20% higher than nameplate full load current, or motor nameplate current multiplied by the transformer ratio (voltage out/voltage in), when a transformer is connected between the controller and motor. Both the overload setpoint, and overload shutdown time delay should be set as low as practical for the application.

Highest Input ø This parameter displays the highest current drawn by either of the three phase leads. The overload condition is calculated upon this highest single phase of motor current. This point is not adjustable.

Alarm Enable This setpoint normally controls whether the controller will shutdown the motor because of an overload condition. In case of the Electrospeed GCS drive, this parameter cannot be disabled and overload protection is permanently enabled.

Lockout Enable This parameter determines if the controller will enter a lockout condition when it has shutdown the motor due to overload. If this point is enabled and the motor is shutdown due to overload, the controller will “lockout” and prevent any further restart attempts until the lockout is cleared. Typical setting is



"YES ", an overload shutdown will lockout automatic restarts.

Bypass Delay Sets the number of tenths of a seconds that the GCS controller will ignore an overload alarm condition that is present at start-up, or that occurs during this bypass period.

Shutdown Delay Sets the number of seconds that the controller will ignore an overload alarm condition that exists while the motor is running, but only after the Overload Bypass Delay timer has expired. The shutdown delay is defined as the delay, in seconds, before the controller shuts the motor off when the current draw exceeds 150% or 1.5 times the overload current setpoint. If the motor current exceeds the overload setpoint, but is either greater than or less than 150% or 1.5 times the setpoint, the controller will either lengthen or shorten the time delay by a mathematical function that simulates motor heating effects. The relationship between current and time delay is established by the constant I^2T, and simply stated, the greater the overload current is, the shorter the time delay will be. In a typical submersible installation the overload time delay might be set for 2 seconds when the current reaches 150% (or 1.5 times) of the overload setpoint.

The I^2T constant would be **$(1.5)^2 * 2 = 4.5$** and the time delay before shutdown is expressed as:

I^2T CONSTANT/(MULTIPLE OF OVERLOAD CURRENT)^2 =
$4.5 / (1.5)^2$ = 4.5 / 2.25 = 2 seconds

If the overload current was to reach 200%, or 2 times the overload setpoint, the time delay to shutdown would be $4.5/(2.0)^2 = 4.5 / 4 = 1.125$ seconds. However, if the VSC is heavily loaded, the controller will protect itself by causing an IOT or Instantaneous Overload Trip shutdown before 200% current is reached. The overload time should be set between two and eight seconds for a submersible motor and 30 to 45 seconds for conventional motors.

Rstrt on Ovld Restart on Overload programs the Overload Auxiliary Restart Parameters (ARPs) to allow the controller one automatic motor restart attempt after an Overload shutdown. All Auxiliary Restart Parameters are accessible from each individual fault and alarm setup screen. However, in the case of Overload, when Rstrt on Ovld is set to yes, the ARP for Overload is activated and the restarts set to one. The illustration at left depicts the ARP settings when this parameter is active.

Aux Rstrt Parms Auxiliary Restart Parameters, when set to "YES ", forces the Electrospeed controller to use

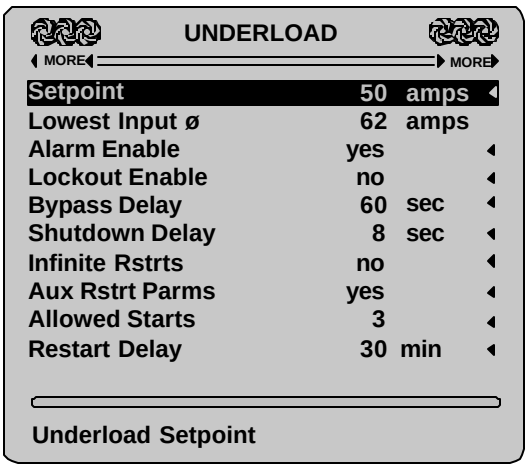
the restart parameters listed below when it shuts down due to an Overload alarm. If this parameter is set to “NO”, the controller will use the global restart parameters when performing an automatic restart. The global restart parameters are set from the Electrospeed GCS setup menus.

Allowed Starts Allowed starts controls how many automatic restarts will be allowed when the controller has shutdown due to Overload and the Aux Rstrt Parms has been set to “YES “.

Restart Delay Restart Delay controls the length of time the controller will wait before attempting to restart the motor when it was shut down due to overload and the Aux Rstrt Parms has been set to “YES “.

UNDERLOAD

This screen gathers the parameters concerning underload protection into one group. Underload alarms protect the motor from insufficient current draw. In submersible pump applications, underload usually indicates loss of cooling due to low volumes of fluid flowing past the motor.



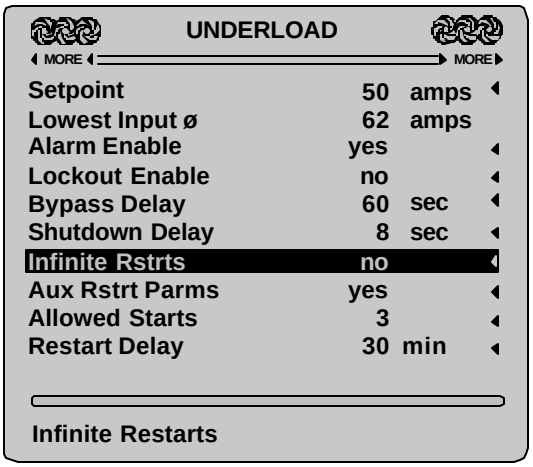
Setpoint The setpoint parameter must be set to the value of motor current below which the controller will shutdown the motor. Typical setting is 15 to 20% below the lowest current phase at minimum output frequency.

Lowest Input ø This parameter displays the lowest current drawn by any one phase. The underload alarm condition is calculated upon this lowest phase motor current. This point is not adjustable.

Alarm Enable This setpoint controls whether the controller will shutdown the motor because of an underload condition or will ignore it. Typical setting is “YES “, underload protection enabled.

Lockout Enable This parameter determines if the controller will enter a lockout condition when it has shutdown the motor due to underload. If this point is enabled and the motor is shutdown due to underload, the controller will “lockout” and prevent any further restart attempts until the condition is cleared. Typical setting is “NO”, do not lockout upon shutdown.

Bypass Delay Sets the number of seconds that the GCS controller will ignore an underload alarm condition that is present at start-up, or occurs during this bypass period. Typical setting is 60 seconds.



Shutdown Delay Sets the number of seconds that the controller will ignore an underload alarm condition that exists while the motor is running, but only after the Underload Bypass Delay timer has expired. Typical setting is 8 seconds.

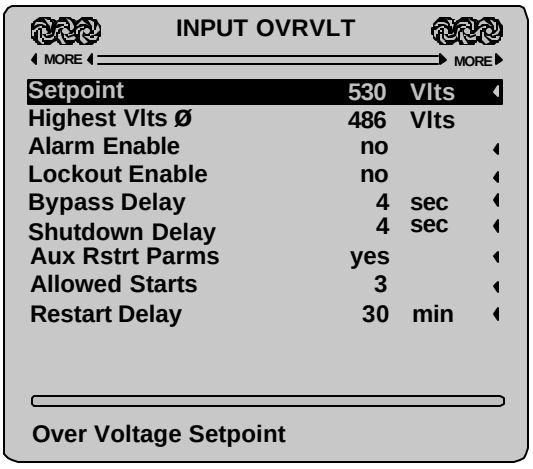
Infinite Rstrts Infinite Restarts, if set to "YES" will cause the drive to allow an infinite number of Underload shutdowns and restarts. The Electrospeed GCS will normally use the Underload Lockout Enable or the Maximum Allowed Restarts parameters to lock out and disallow excessive automatic starts, thereby protecting the motor from repetitive start attempts. There are some situations, however, that require the ability to restart the pump an indefinite number of times when the shutdown cause is Underload. Typical setting is "NO".

Aux Rstrt Parms Auxiliary Restart Parameters, when set to "YES ", forces the Electrospeed controller to use the restart parameters listed below when it shuts down due to an UNDERLOAD alarm. If this parameter is set to "NO", the controller will use the global restart parameters when performing an automatic restart. The global restart parameters are set from the Electrospeed GCS setup menus.

Allowed Starts Allowed starts controls how many automatic restarts will be allowed when the controller has shutdown due to UNDERLOAD and the Aux Rstrt Parms has been set to "YES ".

Restart Delay Restart Delay controls the length of time the controller will wait before attempting to restart the motor when it was shut down due to UNDERLOAD and the Aux Rstrt Parms has been set to "YES ".

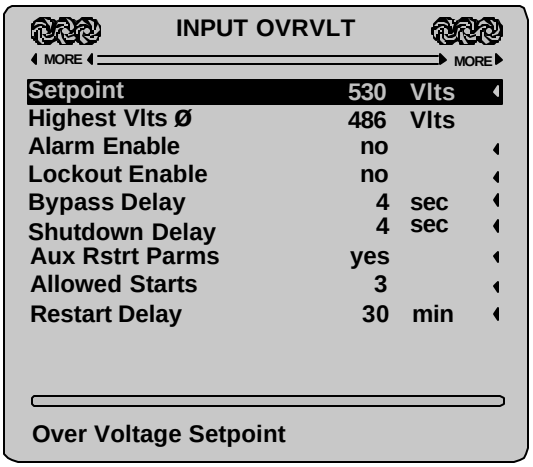
INPUT OVRVLT



This screen gathers the parameters concerning Input Over Voltage protection into one group. Over Voltage alarms protect the Electrospeed GCS from the stresses that will result from excessive input voltage and provide an indication to the operator that power supply problems exist.

Setpoint The Input Over Voltage setpoint parameter must be set to the value of input voltage above which the controller will shutdown the motor. Typical setting is 5% above controller nameplate rating.

Highest Vlts ø This parameter displays the highest of the incoming voltage phases. The over voltage alarm condition is calculated upon this value. This point is not user adjustable.



Alarm Enable This setpoint controls whether the controller will shutdown the motor because of an over voltage condition or will ignore it.

Lockout Enable This parameter determines if the controller will enter a lockout condition when it has shutdown the motor due to over voltage. If this point is enabled and the motor is shutdown due to Over Voltage, the controller will "lockout" and prevent any further restart attempts until the condition is cleared. Typical setting is "NO", do not lockout automatic restarts upon shutdown.

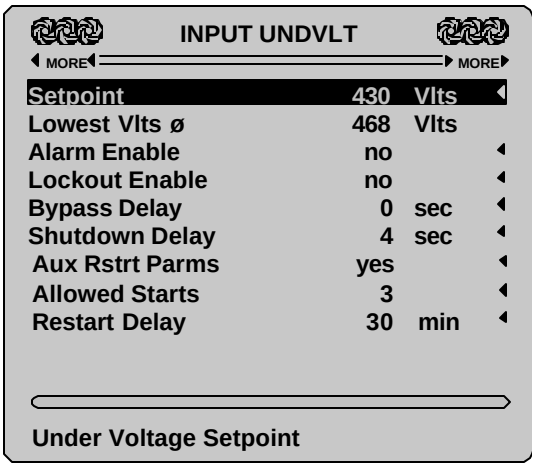
Bypass Delay Sets the number of seconds that the GCS controller will ignore an Over Voltage alarm condition that is present at start-up, or that occurs during this bypass period. Typical setting is 4 seconds.

Shutdown Delay Sets the number of seconds that the controller will ignore an Over Voltage alarm condition that exists while the motor is running, but only after the Over Voltage Bypass Delay timer has expired. Typical setting is 4 seconds.

Aux Rstrt Parms Auxiliary Restart Parameters, when set to "YES ", forces the Electrospeed controller to use the restart parameters listed below when it shuts down due to an Over Voltage alarm. If this parameter is set to "NO", the controller will use the global restart parameters when performing an automatic restart. The global restart parameters are set from the Electrospeed GCS setup menus.

Allowed Starts Allowed starts controls how many automatic restarts will be allowed when the controller has shutdown due to Over Voltage and the Aux Rstrt Parms has been set to "YES ".

Restart Delay Restart Delay controls the length of time the controller will wait before attempting to restart the motor when it was shut down due to Over Voltage and the Aux Rstrt Parms has been set to "YES ".



INPUT UNDVLT

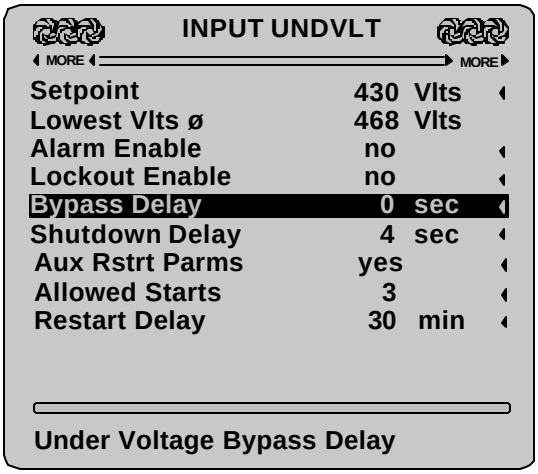
This screen gathers the parameters concerning Input Under Voltage protection into one group. This alarm helps to detect and enunciate power supply problems.

Setpoint The Under Voltage setpoint parameter must be set to the value of input voltage below which the controller will shutdown the motor. Typical setting is 20% below controller nameplate voltage rating.

Lowest Vlts ø This parameter displays value of the lowest phase voltage of all three input phases. The Under Voltage alarm condition is calculated upon this lowest value. This point is not user adjustable.

Alarm Enable This setpoint controls whether the controller will shutdown the motor because of an Under Voltage condition or will ignore it.

Lockout Enable This parameter determines if the controller will enter a lockout condition when it has shutdown the motor due to Under Voltage. If this point is enabled and the drive is shutdown due to Under Voltage, the controller will "lockout" and prevent any further restart attempts until the condition is cleared. Typical setting is "NO", do not lockout automatic restarts upon shutdown.



Bypass Delay Sets the number of seconds that the GCS controller will ignore an Under Voltage alarm condition that is present at start-up, or occurs during this bypass period. Typical setting is 0 seconds.

Shutdown Delay Sets the number of seconds that the controller will ignore a Under Voltage alarm condition that exists while the motor is running, but only after the Under Voltage Bypass Delay timer has expired. Typical setting is 4 seconds. This time delay can be further shortened by a mathematical function that simulates motor heating effects and is established by the constant T/V^2. Simply stated, the lower the input voltage is, the shorter the time delay will be. In a typical submersible installation the under voltage time delay might be set for 4 seconds when the voltage falls below the setpoint (1 times under voltage setpoint). Since the undervoltage setpoint equals 1 times the undervoltage level, the T/V^2 constant would be $4/(1)^2 = 4$. The time delay before shutdown would then be :

(T/V^2 CONSTANT) / ((multiple of undervoltage setpoint)^2)
or **$4/1^2$ = 4 seconds**.

If the under voltage was to reach 200%, or 2 times the Under Voltage setpoint, the time delay to shutdown would

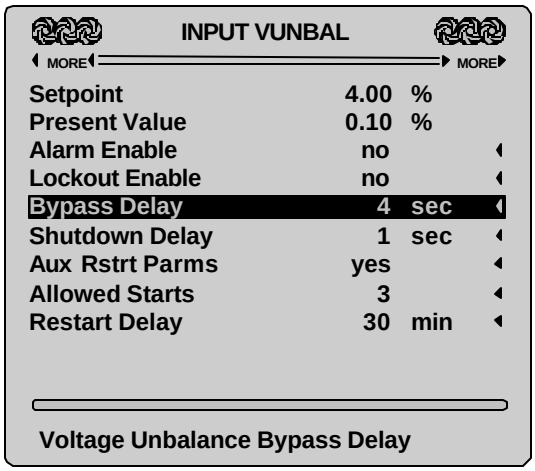
be $4/(2.0)^2 = 4/4$ or 1.00 seconds. The under voltage time is typically set between two and eight seconds for a submersible motor, and 30 to 45 seconds for conventional motors.

Aux Rstrt Parms Auxiliary Restart Parameters, when set to "YES ", forces the Electrospeed controller to use the restart parameters listed below when it shuts down due to an Under Voltage alarm. If this parameter is set to "NO", the controller will use the global restart parameters when performing an automatic restart. The global restart parameters are set from the Electrospeed GCS setup menus.

Allowed Starts Allowed starts controls how many automatic restarts will be allowed when the controller has shutdown due to Under Voltage and the Aux Rstrt Parms has been set to "YES ".

Restart Delay Restart Delay controls the length of time the controller will wait before attempting to restart the motor when it was shut down due to Under Voltage and the Aux Rstrt Parms has been set to "YES ".

INPUT VUNBAL



Input Voltage Unbalance alarms are used to enunciate problems with incoming power. This alarm helps to detect and enunciate power supply problems.

Setpoint The Voltage Unbalance setpoint parameter must be set to the percentage value of input voltage unbalance above which the controller will shutdown the motor. Typical setting is 4 to 10%

Present Value This parameter displays the present percentage value of Voltage Unbalance . This percentage is defined as the maximum deviation of any one phase voltage from the average value of all three phases. The Voltage Unbalance alarm condition is calculated upon this percentage of deviation. This point is not user adjustable.

Alarm Enable This setpoint controls whether the controller will shutdown the motor because of a Voltage Unbalance condition or will ignore it.

Lockout Enable This parameter determines if the controller will enter a lockout condition when it has shutdown the motor due to Voltage Unbalance . If this point is enabled and the motor is shutdown due to Voltage Unbalance, the controller will "lockout" and prevent any further restart attempts until the condition is cleared. Typical setting is "NO", do not lockout automatic restarts upon shutdown.

Bypass Delay Sets the number of seconds that the GCS controller will ignore a Voltage Unbalance alarm condition that is present at start-up, or occurs during this bypass period. Typical setting is 4 seconds.

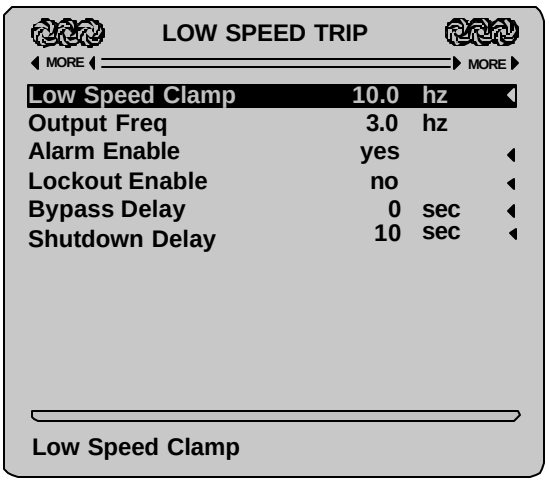
Shutdown Delay Sets the number of seconds that the controller will ignore a Voltage Unbalance alarm condition that exists while the motor is running, but only after the Voltage Unbalance Bypass Delay timer has expired. Typical setting is 1 second.

Aux Rstrt Parms Auxiliary Restart Parameters, when set to "YES ", forces the Electrospeed controller to use the restart parameters listed below when it shuts down due to an Input Voltage Unbalance Alarm. If this parameter is set to "NO", the controller will use the global restart parameters when performing an automatic restart. The global restart parameters are set from the Electrospeed GCS setup menus.

Allowed Starts Allowed starts controls how many automatic restarts will be allowed when the controller has shutdown due to an Input Voltage Unbalance and the Aux Rstrt Parms has been set to "YES ".

Restart Delay Restart Delay controls the length of time the controller will wait before attempting to restart the motor when it was shut down due to an Input Voltage Unbalance and the Aux Rstrt Parms has been set to "YES ".

LOW SPEED TRIP



The Low Speed Trip (LST) setpoint protects the motor from operating below a user selected frequency for longer than the specified time delay.

Low Speed Clamp Low Speed Clamp controls the lowest speed the motor is allow to operate at. Below this frequency, the controller will begin to process a Low Speed Trip shutdown if this alarm is enabled.

Output Freq Output Frequency displays the present operating frequency of the controller. The GCS controller's inverter driver section is always operating at its minimum frequency even if the motor is shutdown, Therefore, this parameter will display a minimum frequency of 3.0 hertz up to a maximum of actual motor output. Output Frequency is not adjustable from this setpoint, although it can be set from the GCS SETUP 1 menu group.

Alarm Enable Low Speed Trip Alarm Enable setpoint controls whether the controller will cause a shutdown due

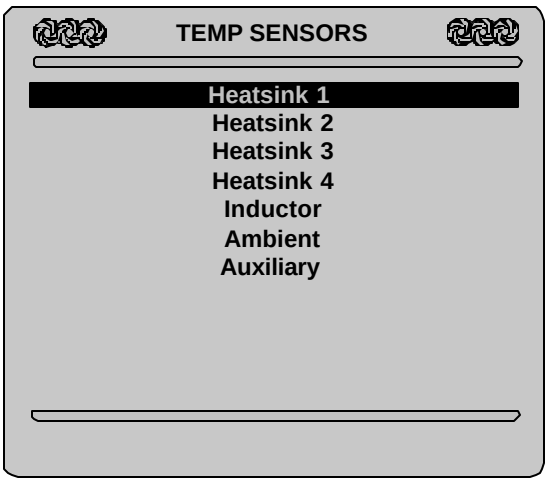
to low output speed. Typical setting is “YES “, LST Alarm is enabled.

Lockout Enable Low Speed Trip Lockout Enable controls whether the controller will enter a lockout condition when it has shutdown due to a Low Speed Trip Alarm condition. If this point is enabled and the motor is shutdown due to Low Speed Trip, the controller will “lockout” and prevent any further restart attempts until the condition is cleared. Typical setting is “NO”, do not lockout upon shutdown.

Bypass Delay Low Speed Trip Bypass Delay sets the number of seconds that the GCS controller will ignore a Low Speed Trip alarm condition that is present at start-up, or occurs during this bypass period. Typical setting is the sum of the Sync Delay plus the Accel Time delays.

Shutdown Delay Low Speed Trip Shutdown Delay sets the number of seconds that the controller will ignore a Low Speed Trip alarm condition that exists while the motor is running, but only after the Low Speed Trip Bypass Delay timer has expired. Typical setting is 10 seconds.

TEMP SENSORS

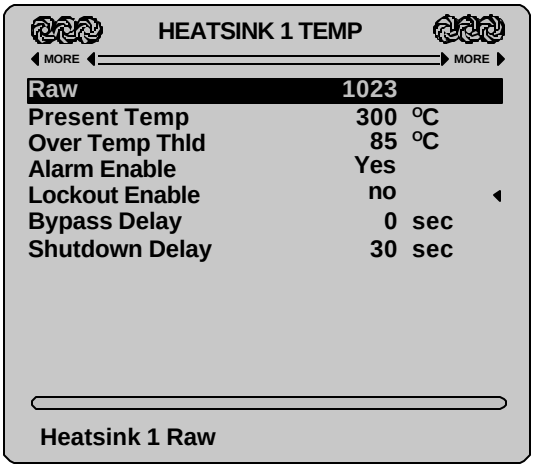


This menu group provides access to the parameters concerning the temperature sensors built into the Electrospeed GCS. Each heat sensor has a setup screen that gathers all the parameters related to that specific sensor. Highlight the desired menu entry with the cursor bar and press enter to access that screen. Note that not all sensors are installed in all drive models. If not installed, the alarm for that sensor will be disabled at the factory. If a temperature sensor fails, it will typically exhibit a “full-scale” raw reading of over 1000.

HEATSINK 1

This screen displays the parameters pertaining to Heatsink number one.

Raw This value represents the un-scaled value of the analog to digital converter reading used to measure the temperature sensors. This parameter is not user adjustable.



Present Temp This value indicates the scaled temperature reading measured on Heatsink 1. This value is not adjustable.

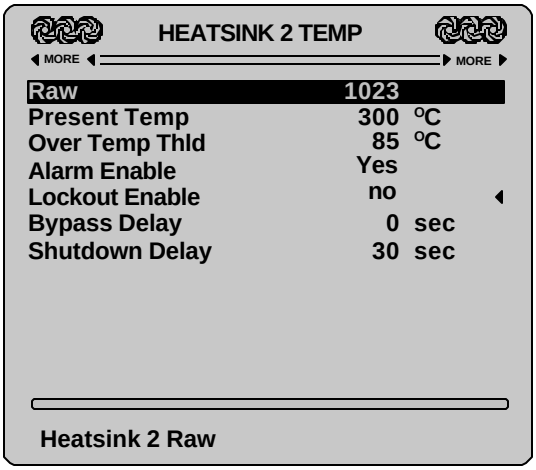
Over Temp Thld Over Temperature Threshold setpoint indicates the temperature value that the controller will permit to occur without causing a shutdown. This value is not user adjustable.

Alarm Enable Alarm Enable setpoint controls if the controller will cause a shutdown due to a temperature reading over the threshold on Heatsink 1. This value is not user adjustable.

Lockout Enable Lockout Enable controls whether the controller will enter a lockout condition when it has shutdown due to a Heatsink 1 Over temperature alarm condition. If this point is enabled and the motor is shutdown due to Heatsink 1 Over temperature, the controller will "lockout" and prevent any further restart attempts until the condition is cleared. Typical setting is "NO", do not lockout upon shutdown.

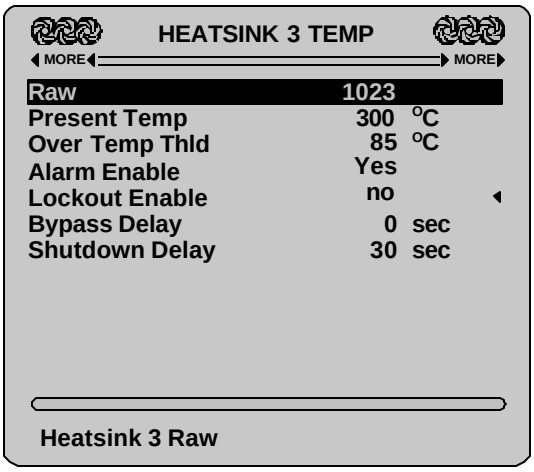
Bypass Delay Bypass Delay sets the number of seconds that the GCS controller will ignore a Heatsink 1 Over temperature alarm condition that is present at start-up, or occurs during this bypass period. This value is not user adjustable.

Shutdown Delay Shutdown Delay determines the number of seconds that the GCS controller will ignore a Heatsink 1 Over temperature alarm condition which exists while the motor is running, but only after the Heatsink 1 Over temperature Bypass Delay timer has expired. Typical setting is 10 seconds. This value is not user adjustable.



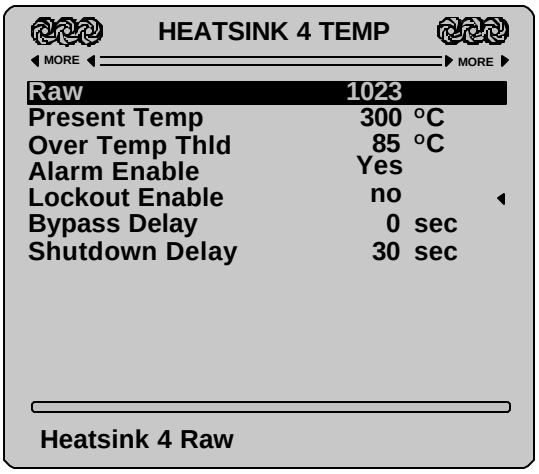
HEATSINK 2

This screen displays the parameters pertaining to Heatsink number two. All parameters are used in the same fashion as those parameters for Heatsink 1. Refer to that section of the manual for further explanation of the parameters. The values shown in the graphic represent the typical settings for this heat sensor. With the exception of Lockout Enable, these values are not user adjustable.



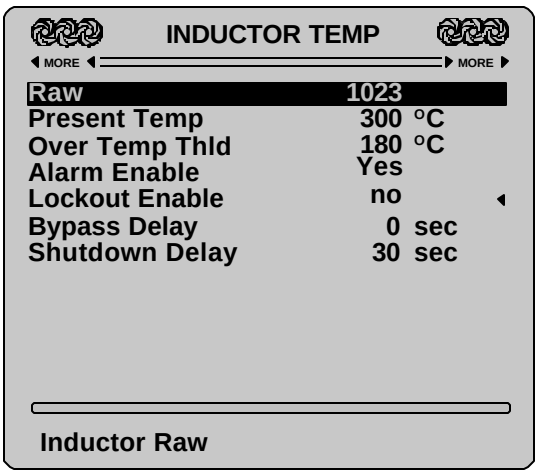
HEATSINK 3

This screen displays the parameters pertaining to Heatsink number three. All parameters are used in the same fashion as those parameters for Heatsink 1. Refer to that section of the manual for further explanation of the parameters. The values shown in the graphic represent the typical settings for this heat sensor. With the exception of Lockout Enable, these values are not user adjustable.



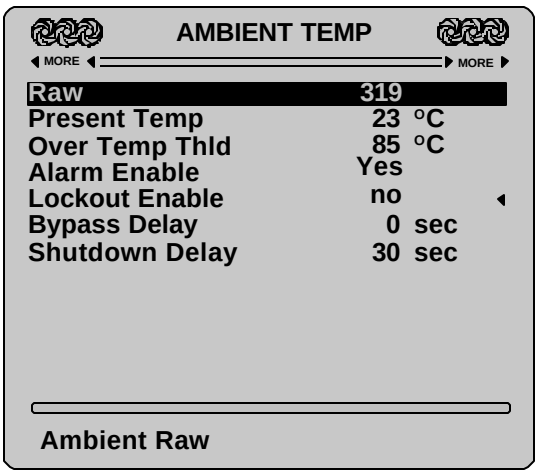
HEATSINK 4

This screen displays the parameters pertaining to Heatsink number four. All parameters are used in the same fashion as those parameters for Heatsink 1. Refer to that section of the manual for further explanation of the parameters. The values shown in the graphic represent the typical settings for this heat sensor. With the exception of Lockout Enable, these values are not user adjustable.



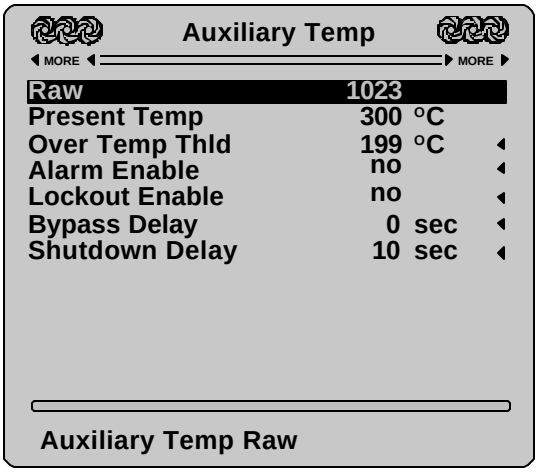
INDUCTOR TEMP

This screen displays the parameters pertaining to Inductor Temperature. All parameters are used in the same fashion as those parameters for Heatsink 1. Refer to that section of the manual for further explanation of the setpoints. The values shown in the illustration represent the typical settings for this heat sensor. With the exception of Lockout Enable, these values are not user adjustable.



AMBIENT TEMP

This screen displays the parameters pertaining to Ambient Temperature. All parameters are used and set in the same fashion as those parameters for Heatsink 1. Refer to that section of the manual for further explanation of user setpoints. The values shown in the illustration represent the typical settings for this heat sensor. With the exception of Lockout Enable, these values are not user adjustable.

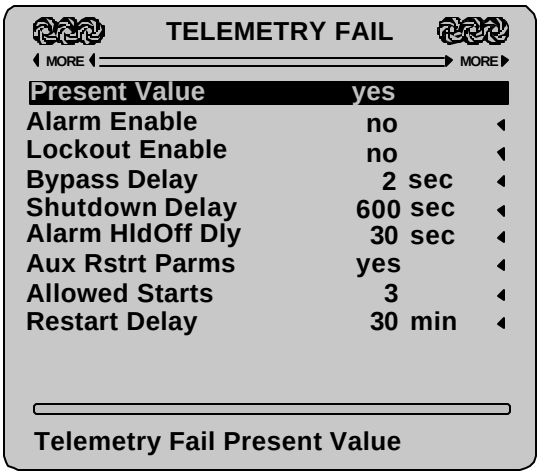


AUXILIARY TEMP

This screen displays the parameters pertaining to Auxiliary Temperature. All parameters are used and set in the same fashion as those parameters for Heatsink 1. Refer to that section of the manual for further explanation of user setpoints. The values shown in the illustration represent the typical settings for this heat sensor. The parameters that are adjustable have a small arrowhead displayed on the right side of the screen line.

TELEMETRY FAIL

This alarm screens allows access to the parameters associated with a telemetry failure alarm. A Telemetry Failure alarm is defined as existing when a valid message destined for this controller is not received within the associated time delays. This type of alarm can be useful when the Electrospeed GCS controller is connected to a telemetry or SCADA system and the pump must not be allowed to operate during a communications failure. For example, this alarm could be used to shutdown a water source well used to feed a process facility when the communication and/or control system in that facility fails.



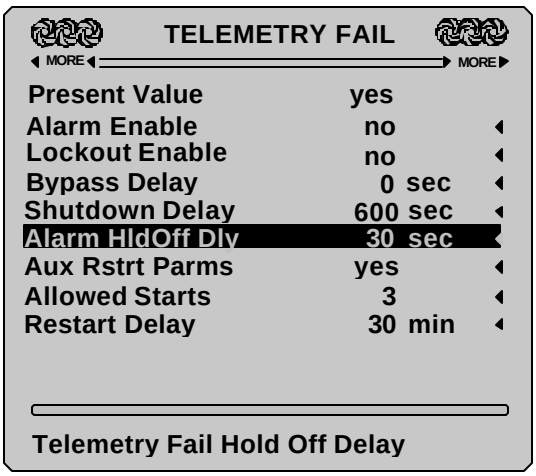
Present Value This data variable displays the current status of the Telemetry Failure alarm. If this point reads "YES " and the alarm is enabled, the controller will shut down the motor after the associated time delays have expired. An alarm is considered to be active when the controller is not actively receiving a message for this unit or transmitting a reply to a valid message. Therefore, when enabled, the present value will change from "YES " to "NO" when it is actively communicating. The associated time delays discussed below allow the user to adjust the length of time before any action is taken due to this alarm.

Alarm Enable This setpoint controls whether this Telemetry alarm will cause the controller to shutdown the motor when a communications alarm occurs.

Lockout Enable This setpoint controls whether the controller will or will not attempt an automatic restart when the motor has been shutdown because of a Telemetry alarm. If it is set to "YES " and a Telemetry Alarm shutdown occurs, the controller will "lockout" and prevent any further start attempts.

Bypass Delay This setpoint represents the amount of time in seconds that the controller will ignore an existing Telemetry Alarm after a start. If a non-zero value is entered into this parameter, the controller will start the motor even while the alarm exists. If the communications system is indeed not operating, this is not desirable because the motor will shutdown again as soon as the associated delays expire. Instead, use the Alarm Hold Off Delay timer to control whether the controller restarts while a communications alarm exists.

Shutdown Delay This parameter represents the amount of time in seconds that the controller will allow a Telemetry Alarm to exist before shutting down the motor. This alarm time should be set to slightly longer than the total cycle time of the host SCADA computer. For example, if the SCADA host scans this particular controller every nine minutes, the alarm could be set to 600 seconds or 10 minutes. If the host SCADA system does not communicate with this controller within that time delay, its motor will be shutdown automatically.

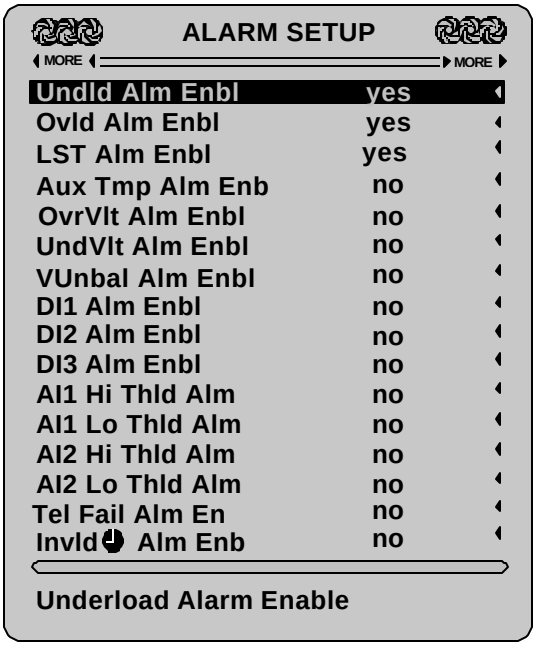


Alarm HldOff Dly The Alarm Hold Off Delay parameter controls whether the controller will allow the motor to be started while the telemetry alarm exists. If a bypass delay is entered into this parameter and the communications system is not operating, the controller will start the motor and probably only run until the Bypass and Shutdown delays expire. This situation will repeat and can result in numerous unnecessary motor starts and even damage. This unique Hold Off Delay lets the controller listen for and determine whether any communications traffic exists on the telemetry system. If valid communications messages exist, it is assumed that a telemetry system is in place and functioning and the motor is allowed to start. In this case, the central SCADA computer must then communicate to this specific GCS controller within the Bypass plus the Shutdown Delay to prevent a motor shutdown. Note that unlike the Bypass and Lockout time delays, this Alarm Holdoff Delay timer is re-triggered by any data traffic, not only messages destined for this unit.

Aux Rstrt Parms When set to “YES”, the Auxiliary Restart Parameters setpoint causes the Electrospeed controller to use the restart parameters listed below when it shuts down due to a Telemetry Fail alarm. If this parameter is set to “NO”, the controller will use the global restart parameters when performing an automatic restart. The global restart parameters are set from the Electrospeed GCS setup menus.

Allowed Starts Allowed starts controls how many automatic restarts will be allowed when the controller has shutdown due to Telemetry Fail and the Aux Rstrt Parms has been set to “YES “.

Restart Delay Restart Delay controls the length of time the controller will wait before attempting to restart the motor when it was shut down due to Telemetry Fail and the Aux Rstrt Parms has been set to “YES “.



ALARM SETUP

The alarm setup screen is provided as a convenience to the user so that most of the alarm conditions can be enabled or disabled within one screen.

These alarm configuration screens are found in the FAULTS & UNDLD menu group.

Undld Alm Enbl	Underload Alarm Enable
Ovld Alm Enbl	Overload Alarm Enable
Low Speed Trip	Low Speed Alarm Enable
Aux Tmp Alm Enb	Auxiliary Temperature Alarm
OvrVlt Alm Enbl	Input OverVoltage Alarm
UndVlt Alm Enbl	Input UnderVoltage Alarm
Vunbal Alm Enbl	Input Voltage Unbalance Alarm
Tel Fail Alm En	Telemetry Failure Alarm Enable

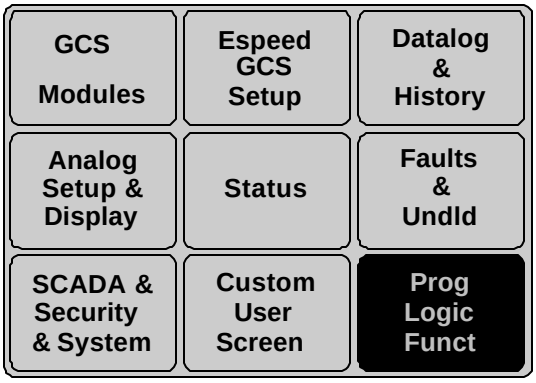
These Alarm configuration screens are found in the GCS MODULES / ONBOARD I/O menu screens.

DI1 Alm Enbl	Digital Input 1 Alarm Enable
DI2 Alm Enbl	Digital Input 2 Alarm Enable
DI3 Alm Enbl	Digital Input 3 Alarm Enable
AI1 Hi Thld Alm	Analog Input 1 High Threshold Alarm Enable
AI1 Lo Thld Alm	Analog Input 1 Low Threshold Alarm Enable
AI2 Hi Thld Alm	Analog Input 2 High Threshold Alarm Enable
AI2 Lo Thld Alm	Analog Input 2 Low Threshold Alarm Enable

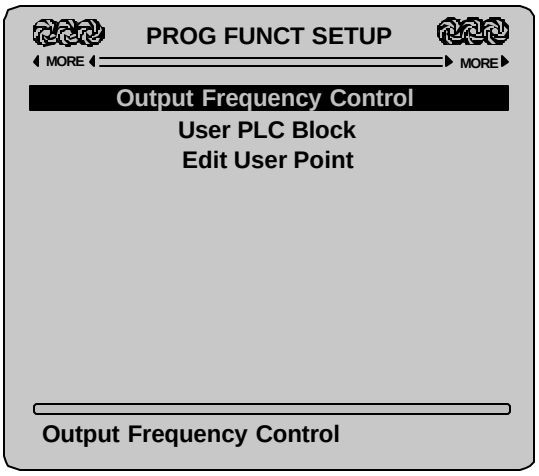
This invalid time alarm's configuration screen is the CURRENT TIME screen.

Invld Alm Enb	Invalid Time Alarm Enable

PROGRAMMABLE LOGIC FUNCTIONS

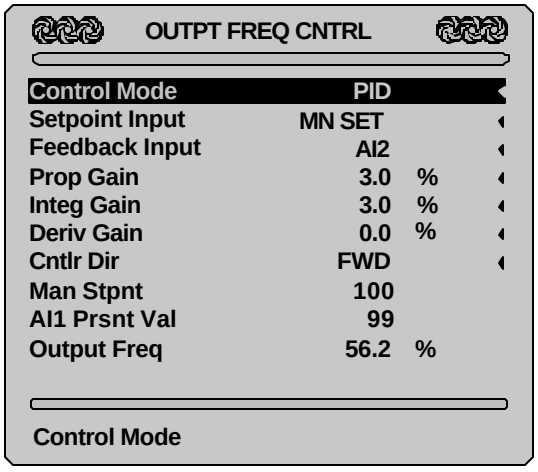


The programmable logic functions group of screens provides access to the programmable functions of the Electrospeed GCS. At present only Output Frequency Controls are included as pre-programmed functions. As additional functions become available, they will be accessed via these menus. However, by utilizing the User Programmable Logic controller (UPLC) functions, many different types of control algorithms can be created.



PROG FUNCT SETUP

The Programmable Function setup screen provides access to the available functions.



OUTPUT FREQUENCY CONTROL

The Output Frequency Control setup screen provides the user with three modes of output speed control; PID, Analog Follower and Frequency Setpoint. When the user selects one of the three modes, the bottom portion of the screen will change to display the parameters pertaining to that type of control algorithm.

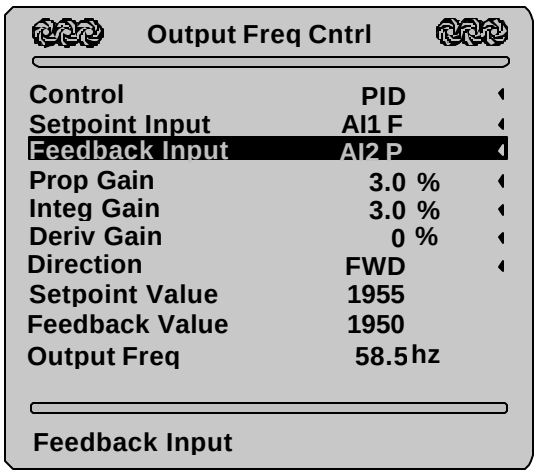
Control Mode Control Mode determines which algorithm will control the output speed of the drive. Each of the three algorithms uses a set of variables that control its operation. Select the operating mode first, and the rest of the screen will change to display the parameters appropriate for that control method.

Control Mode: PID When operating in PID mode, the controller will attempt to vary its output frequency in order to maintain a given analog input signal.

Setpoint Input The setpoint input dictates which control value or input signal will be used as the target that the controller will attempt to reach and maintain.

Available inputs are:

MN SET (Manual Setpoint) The controller will vary its output frequency to achieve this value of feedback signal. The engineering units entered here must match the units of the selected feedback input.
AI1 (Analog Input 1) The current calibrated and scaled value of the analog signal present on Analog input 1.
AI2 (Analog Input 2) The current calibrated and scaled value of the analog signal present on Analog input 2.
X1 AI1, AI2 (Expansion I/O module 1, Analog input 1 or 2) the calibrated value of the analog signal present on analog input 1 or 2 of expansion I/O module 1.
X2 AI1, AI2 (Expansion I/O module 2, Analog input 1 or 2) the calibrated value of the analog signal present on analog input 1 or 2 of expansion I/O module 2.
X3 AI1, AI2 (Expansion I/O module 3, Analog input 1 or 2) the calibrated value of the analog signal present on analog input 1 or 2 of expansion I/O module 3.
TRK C1..C8(Tracker GCS input channel 1 ..8) These values are retrieved from a Tracker GCS module attached to the CITIBus.



Feedback Input The feedback input determines which signal will be used as feedback to the PID control algorithm. Note that the algorithm will not function properly if the setpoint input and the feedback input are set to the same analog input.

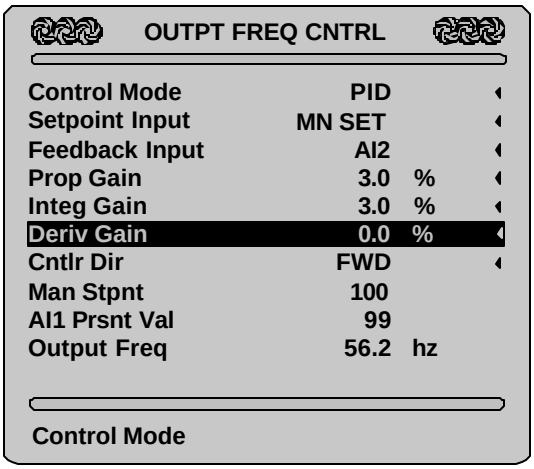
Available inputs are:

MN SET (Manual Setpoint) The controller will vary its output frequency to achieve this value of feedback signal. The engineering units entered here must match the units of the selected feedback input.
AI1 (Analog Input 1) The current calibrated and scaled value of the analog signal present on Analog input 1.
AI2 (Analog Input 2) The current calibrated and scaled value of the analog signal present on Analog input 2.
X1 AI1, AI2 (Expansion I/O module 1, Analog input 1 or 2) the calibrated value of the analog

signal present on analog input 1 or 2 of expansion I/O module 1.
X2 AI1, AI2 (Expansion I/O module 2, Analog input 1 or 2) the calibrated value of the analog signal present on analog input 1 or 2 of expansion I/O module 2.
X3 AI1, AI2 (Expansion I/O module 2, Analog input 1 or 2) the calibrated value of the analog signal present on analog input 1 or 2 of expansion I/O module 2.
TRK C1..C8(Tracker GCS input channel 1 ..8) These values are retrieved from a Tracker GCS module attached to the CITIBus.

Integ Gain Integral Gain is set as a percentage value (0 to 100%) and represents the integral gain component of the PID control algorithm. Typical setting is 3%. Every time the control algorithm is updated, the controlling analog input value is compared to the setpoint. The difference between the two represents the “error”. The output speed demand is increased or decreased by an amount proportional to the product of the “error” and the Integral Gain. Simply put, the greater the “error” value, or the higher the gain is set, the greater the change will be.

Prop Gain Proportional Gain is set as a percentage value (0 to 100%) and represents the proportional gain component of the PID control algorithm. Typical setting is 3%. Each time the PID control algorithm is recalculated, an amount proportional to the product of the “error” and the proportional gain is added or subtracted from the output speed demand. The proportional gain component of the algorithm modifies the speed demand to reduce the response time of the system.



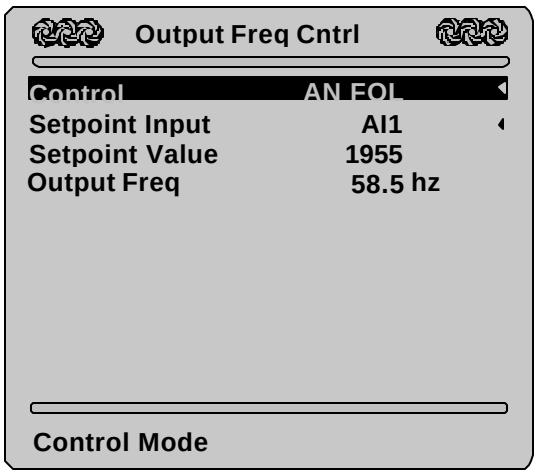
Deriv Gain Derivative Gain is set as a percentage value (0 to 100%) and represents the derivative gain component of the PID control algorithm. Typical setting is 0%. The derivative gain component is calculated as the product of the difference between the last two analog input readings (the feedback). This component will decrease the speed demand if the difference is negative and will increase the speed demand if the difference is positive. The derivative gain, therefore, is either added or subtracted from the speed demand to limit the overshoot in systems where a fast response is necessary.

Cntlr Dir Controller Direction controls the polarity (Direct Acting (FWD) or Reverse Acting (REV)) in which the PID algorithm will apply the speed adjustments. In direct acting, the drive will increase its output frequency in response to an increase in the setpoint. Reverse acting

decreases the output frequency in response to an increasing setpoint.

Man Stpnt Manual Setpoint displays the value of the user entered manual setpoint that the Electrospeed GCS will try to cause the feedback input to match. The drive will increase (or decrease) its output frequency to attempt to accomplish this. If any analog input is selected as the setpoint, then the value of that input is displayed here instead.

AI1 Prsnt Val Analog Input 1, Present Value displays the current value of the signal selected as the feedback signal to the drive's PID control loop. If any other analog input is selected as the setpoint, then the value of that input is displayed here instead.

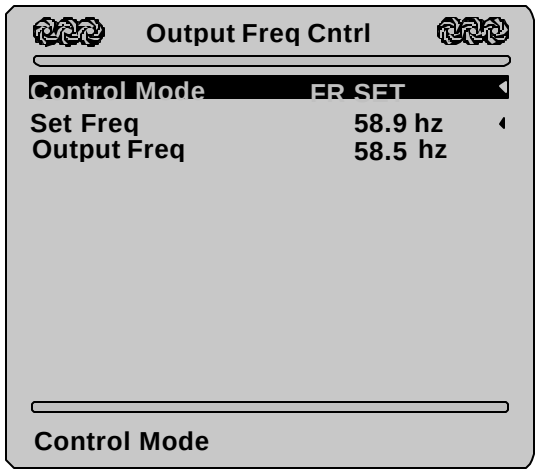


Control Mode: AN FOL Analog Follower When operating in Analog Follower Control mode, the controller will attempt to vary its output frequency between the Low Speed Clamp and High Speed Clamp in proportion to 0-100% of the analog input signal selected.

Setpoint Input The setpoint input dictates which input signal the Electrospeed will attempt to follow. The available inputs are the same as the PID control mode but excludes the Manual Setpoint.

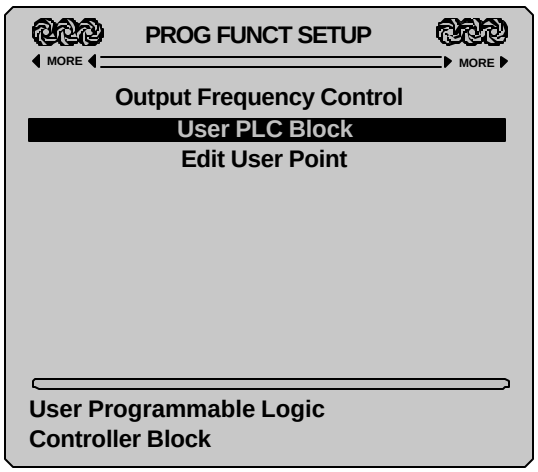
Setpoint Value Setpoint Value displays the present value of which ever analog input is selected as the setpoint.

Output Freq Output Frequency displays the present output frequency that the Electrospeed GCS is currently producing.



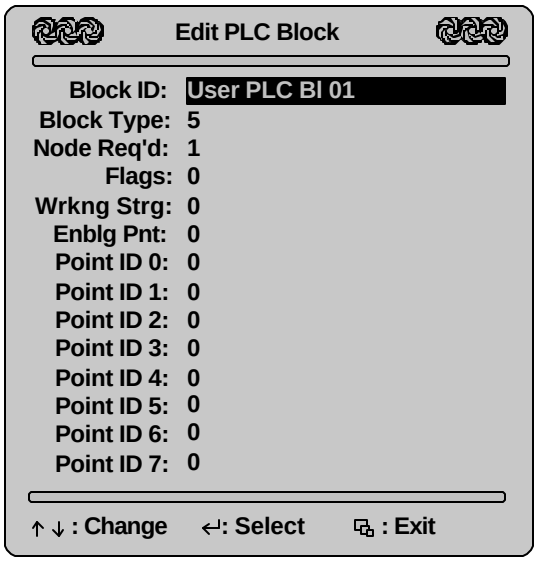
Control Mode: FR SET When the Electrospeed GCS is operating in Frequency setpoint mode, it will attempt to operate at the user programmed set frequency. Several factors may affect the controller's ability to achieve this frequency including, ILimit, High Speed Clamp and Low Speed Clamp.

Set Frequency This user set parameter is the requested operating frequency of the drive. This setpoint can also be entered via the Espeed GCS Setup 1 screen.



USER PLC BLOCK

The User PLC Block menu provides user access to the execution control block that drives the programmable logic function controller. Using the functions provided, the user can create custom, unique control algorithms that are not available within the standard controller. The information and description provided in this manual is brief, however, Appendix J in this manual provides more details and examples.



EDIT PLC BLOCK

The Edit PLC Block screen allows the user to enter or edit any of the PLC Block variables. There are 48 User PLC Blocks available, numbered 1 through 48. When identified within a User PLC point, the blocks are identified by their database address number with block number one equaling address 99, block number two equaling address 98, and so on. The last PLC block available is block number 48, at address 52.

Block ID The Block ID variable indicates which PLC Block is presently shown on the screen. The illustration shows User PLC Block #01 displayed. Move the cursor to highlight this item and press the left/right arrow keys to show the last/next block

Block Type The User PLC block type determines what type of function this block will perform. Block Type 5 is general purpose

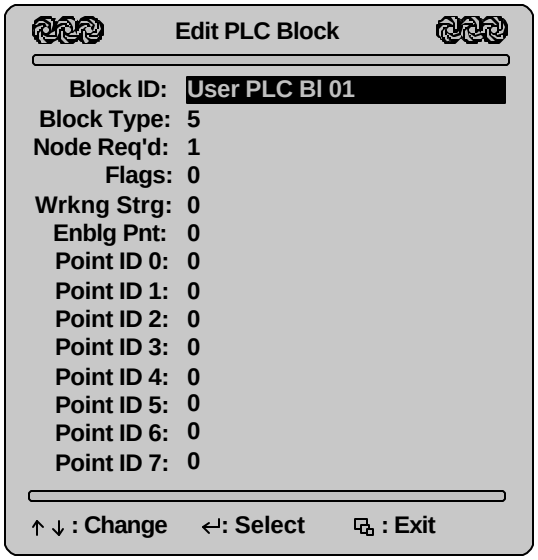
Node Req'd The Node Required variable is used to allow or disallow the calculation of a User PLC function based on whether the specified CITIBus node is online and active. If the specified node is not active, the User PLC block will not be executed.

Flags The Flags variable controls execution of the PLC block.

Wrkng Strg Working Storage is a variable used internally by the GCS controller.

Enblg Pnt Enabling Point is used to allow / disallow execution of this User PLC block. Enter the Point ID number of a valid, enabled alarm chain to activate this

PLC block. When the named alarm chain is enabled, this User PLC block will also be enabled and processed.



Point ID 0 Point ID 0 holds the user database point number of the first point to execute. Valid entries are point ID 4095 through point ID 3840. The User PLC routine will execute any points listed before the point ID with a zero value. If valid point ID's exist in any subsequent point ID's, they will not be executed.

Point ID 1 Point ID 1 holds the user database point number of the second point to execute. Valid entries are point ID 4095 through point ID 3840.

Point ID 2 Point ID 2 holds the user database point number of the third point to execute. Valid entries are point ID 4095 through point ID 3840.

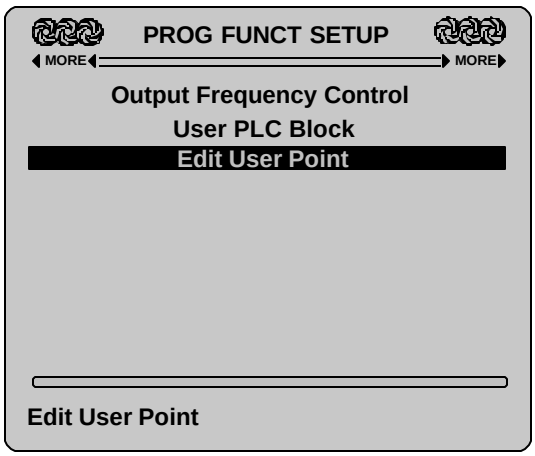
Point ID 3 Point ID 3 holds the user database point number of the fourth point to execute. Valid entries are point ID 4095 through point ID 3840.

Point ID 4 Point ID 4 holds the user database point number of the fifth point to execute. Valid entries are point ID 4095 through point ID 3840.

Point ID 5 Point ID 5 holds the user database point number of the sixth point to execute. Valid entries are point ID 4095 through point ID 3840.

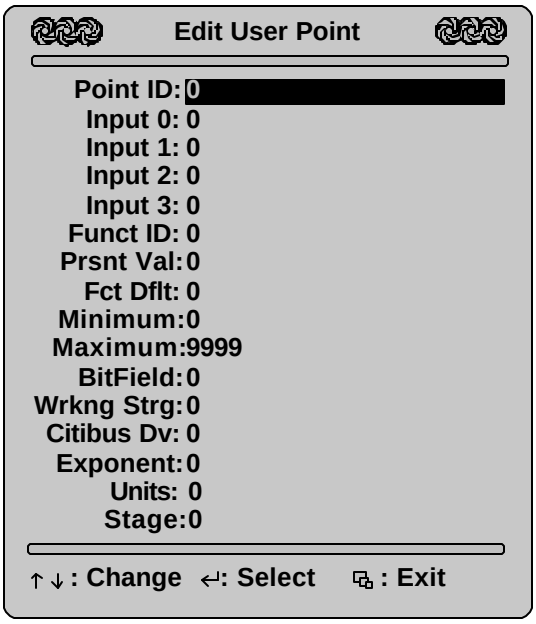
Point ID 6 Point ID 6 holds the user database point number of the seventh point to execute. Valid entries are point ID 4095 through point ID 3840.

Point ID 7 Point ID 7 holds the user database point number of the eighth point to execute. Valid entries are point ID 4095 through point ID 3840.



EDIT USER POINT

The Edit User Point menu, in conjunction with the User PLC Block menus, provides access to the user database points used to perform calculations and logical functions.



Point ID: The Point ID variable is used to Identify which database point is being displayed or edited. Move the cursor to this location and press the left / right arrow keys to display the previous / next User database point. Press the ENTER key to be allowed to enter the actual point number of any User point. The GCS controller has 256 User Database points available.

Input 0: This variable is used to indicate the first point ID that will be used by this User PLC function. This point can be set to the number of any of the available database points in the GCS controller and is not limited to the 256 user database point addresses. A complete list of addressable database points is available in the applications guide.

Input 1: This variable is used to indicate the second point ID that will be used by this User PLC function. This point can be set to the number of any of the available database points in the GCS controller and is not limited to the 256 user database point addresses.

Input 2: This variable is used to indicate the first point ID that will be used by this User PLC function. This point can be set to the number of any of the available database points in the GCS controller and is not limited to the 256 user database point addresses.

Input 3: This variable is used to indicate the first point ID that will be used by this User PLC function. This point can be set to the number of any of the available database points in the GCS controller and is not limited to the 256 user database point addresses.

Funct ID: The function ID variable holds the number identifier of the required function. These functions are listed in APPENDIX J.

Prsnt Val: The Present Value parameter contains the current numerical value of this point.

Fct Dflt: The Factory default of the present value for this user database point is held in this variable.

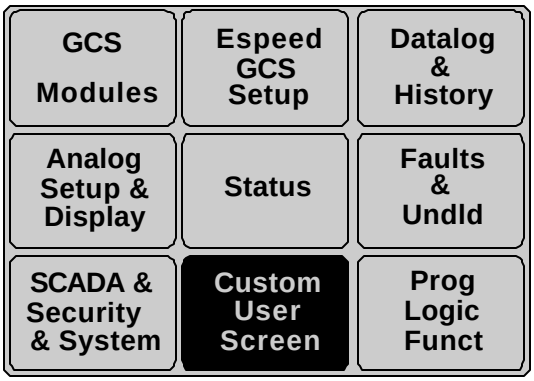
Minimum: The minimum value of this user database point.

Maximum: The maximum value of this user database point.

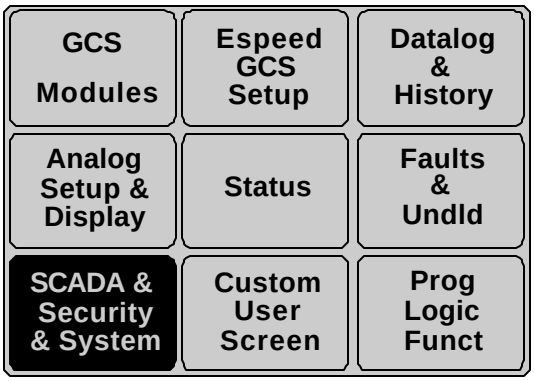
Bitfield: The bitfield variable contains a bit-coded value that classifies the database point according to the value contained. Appendix J describes the available settings.

Stage: Reserved

CUSTOM USER SCREEN

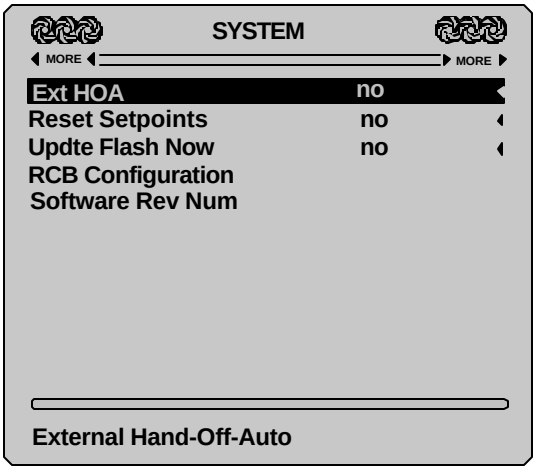


The Custom User Screen menu item provides the point of entry to customized display screens that can be user designed. As features and functions become available, they will be distributed as software field upgrades.



SCADA & SECURITY & SYSTEM

The group SCADA & Security & System of screens provide access to several system maintenance, security and communication options features within the Electrospeed GCS.



SYSTEM

This screen provides access to several parameters concerning overall system maintenance.

Ext HOA This parameter, External HAND-OFF-AUTO (HOA) switch, controls whether the GCS controller uses its onboard digital inputs as control inputs for an externally or remotely mounted HOA switch. When this parameter is enabled, Digital inputs 1 and 2 are dedicated to this HOA function and cannot be used for general-purpose status inputs. The state of these inputs then dictate whether the GCS will operate in AUTO mode (automatic restarts) or HAND (manual restarts only). The center or OFF position of this switch is interpreted as a

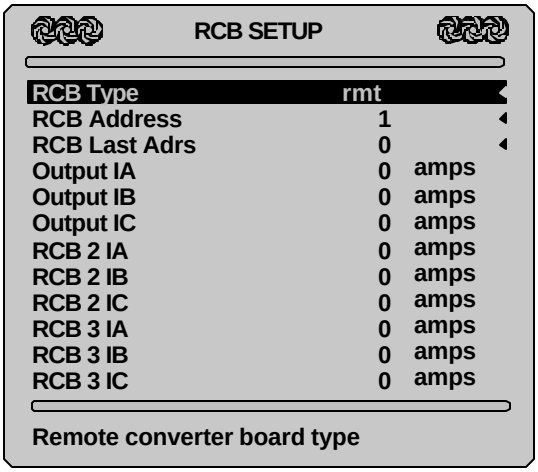
manual shutdown command. See basic operation for information regarding operating modes.

Reset Setpoints This control setpoint will cause the GCS controller to reprogram all of its parameter and setpoint values back to the factory default settings. The function will also reset all running / downtime accumulators and start counters back to the zeroed state. This is typically used when a controller is being moved or re-deployed into another motor control situation. It provides a known, conservative starting point for user setup.

Updte Flash Now The Update Flash Now parameter instructs the controller to immediately copy all of its internal parameters, setpoints and values to the onboard non-volatile flash memory storage device. This function will only work properly when the motor is not running. If the motor is running when this setpoint is set to “YES”, the display will read “err” and the memory will not be updated. The flash memory storage contains the program, database code as well as user setpoints. It is used at a power on time to verify and if necessary, replace the battery backed RAM copies of software. Whenever the RAM copy of the setpoints are valid, but differ from the flash memory copy, the controller will automatically update the flash memory copy at power up time. If the controller’s memory backup battery has failed or is discharged, the user can execute this command to preserve their configuration in the event of a power failure.

RCB Configuration Remote Converter Board Configuration is used to access the menu for setting up additional power converter control circuit boards. Highlight this item and press ENTER to access the subsequent menu.

Software Rev Num The software revision levels of the GCS modules connected together in this control system are listed here. Highlight this item and press ENTER to access the subsequent menu.



RCB SETUP

Remote Converter Board setup is used to configure the Electrospeed GCS to use more than one power conversion control board. Using multiple converters reduces the amount of harmonic distortion reflected back unto the power supply feeding the drive. Contact Centrilift's Control Technologies group for availability and further information.

RCB Type The Remote Converter Board type can be set.

RCB Address The Remote Converter Board address can be set to 1 through 4.

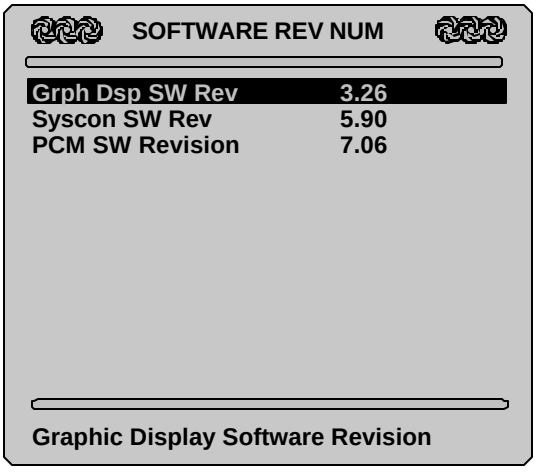
RCB Last Address The number of the highest addressed remote board installed.

Output IA IB & IC The output current of the drive on all three phases are displayed.

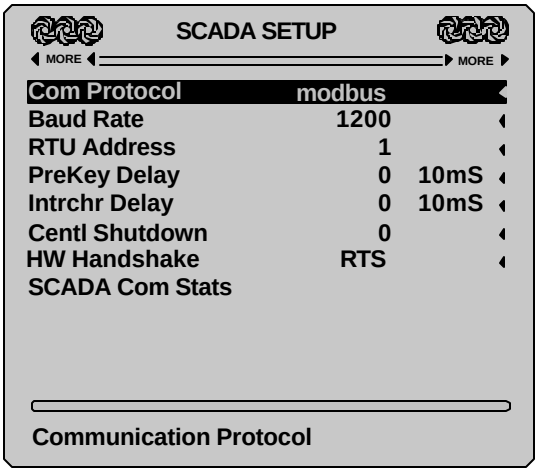
RCB 2 IA IB & IC The input currents drawn on the three phases of remote converter board 2 are shown on these variables.

RCB 3 IA IB & IC The input currents drawn on the three phases of remote converter board 3 are shown on these variables.

RCB 4IA IB & IC The input currents drawn on the three phases of remote converter board 4 are shown on these variables



Software Rev Num The software revision levels of the GCS modules connected together in this control system are listed here. Highlight this item and press ENTER to access the subsequent menu.



SCADA SETUP

The SCADA SETUP menu groups together the related parameters controlling communications to external computer systems and telemetry devices. Press the right ARROW key from the SYSTEM menu to access this menu.

Com Protocol Communication Protocol allows the user to select the communication language that the controller will use to electronically communicate to telemetry and computer systems. Typical setting is MODBUS™ RTU Refer to the MODBUS™ register address table in the appendix section for detailed information.

Baud Rate Baud rate sets the speed of serial communication with telemetry and computer systems. Supported rates are 1200 to 9600 baud.

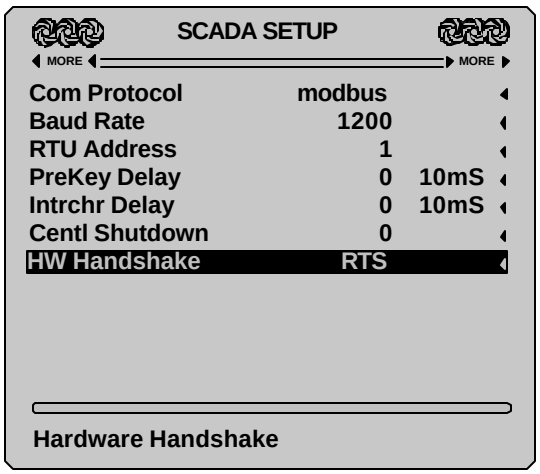
Serial settings are No Parity, 1 Start, 1 Stop, 8 Data Bits

Rtu Address Remote Terminal Unit Address is the variable that assigns a number from 1 to 255 to this controller for the purpose of identifying itself within a communication network.

PreKey Delay PreKey Delay implements a “Push to Talk” or “Request To Send (RTS)” delay timer that is used to assert the “RTS” output at the RS-232 Communication Port for a user specified time before commencing serial data transmitting. This signal and/or delay is commonly used to handshake or synchronize two communication devices. In two-way radio systems, this RTS can be used as the “Microphone/Transmit” signal to enable the radio transmitter prior to serial data output.

Intrchr Delay Inter-character delay is a user set variable that controls the allowable time delay between adjacent serial characters of an active message.

Centl Shutdown Central Shutdown is a system status variable that is dedicated to enunciating the presence of a SCADA or User PLC motor shutdown command. When this variable is set to any other value than 0 (zero), the controller will stop the motor if running and disallow further restart attempts until cleared. Although this variable can be cleared locally, be cautious if doing so, since another control person or process may require and depend on this unit to remain off.



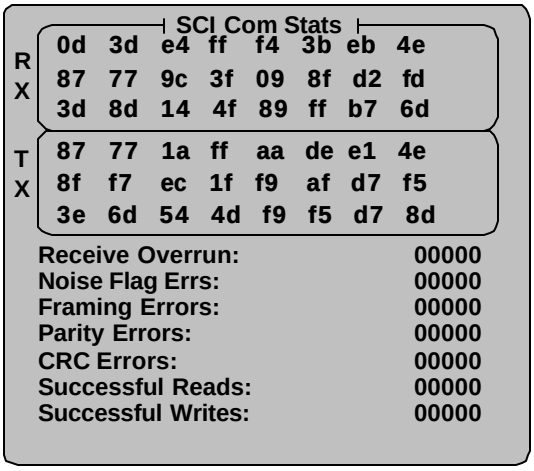
HW Handshake HardWare Handshake is a three state variable that controls the type of communication synchronization that is active.

Possible settings are: none, RTS or R/CTS.

None selects a three wire serial communication port setting, (RX,TX,GND).

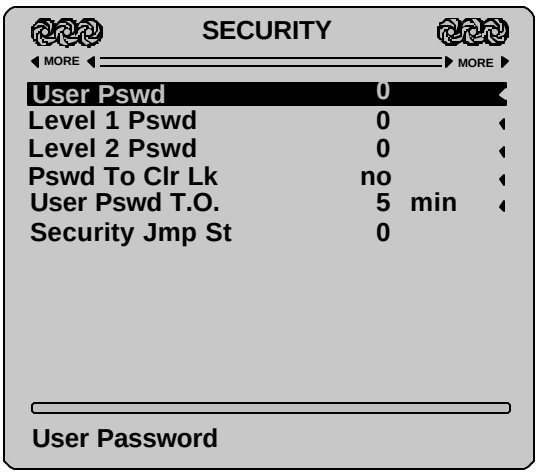
RTS selects a four wire serial communication port setting, (RX,TX,RTS,GND). When RTS is active, when transmitting, the controller will assert the RTS signal line for a time period equal to the value set into the PreKey Delay parameter previously discussed. After this time delay has expired, the data is transmitted.

R/CTS selects a five wire serial communication port setting, (RX,TX,RTS,CTS,GND). When RTS/CTS is active, when transmitting, the controller will assert the RTS signal line and wait until the CTS line is also asserted by the external modem. Once the CTS line is asserted, then the GCS controller will transmit its data.



SCADA COM STATS

This screen displays information pertaining to the operation of the communication control registers. It is useful for diagnosing serial communications with telemetry equipment. It displays accumulators for several error and message counters as well as the first 24 bytes of the receive and transmit memory buffers.



SECURITY

This menu accesses the system security features of the Electrospeed GCS. Press the right ARROW key from the SCADA SETUP menu to reach this screen.

User Pswd This parameter, USER PASSWORD, contains the user's security password. It can entered here or via the Espeed GCS SETUP screen.

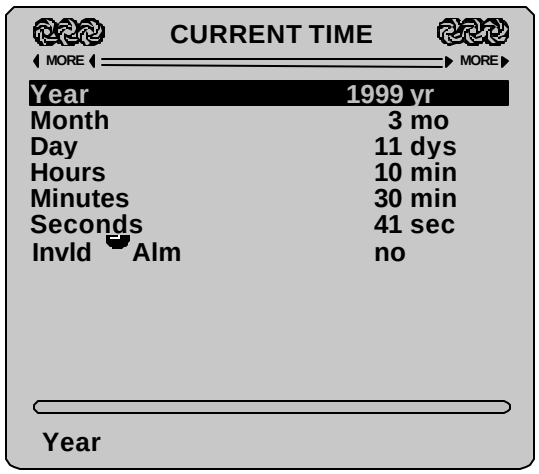
Level 1 Pswd Level one password is the value that must be entered into the USER PASSWORD parameter to gain edit access to most setpoints. If the user password does not equal this one, this variable will display XXXXX.

Level 2 Pswd Level two password is the value that must be entered into the USER PASSWORD parameter to gain edit access to all setpoints and system configuration variables. If the user password does not equals this one, this variable will display XXXXX

Pswd To Clr Lk Password to Clear Lockout controls whether a valid password must be entered before the user is allowed to clear a lockout condition and restart the motor.

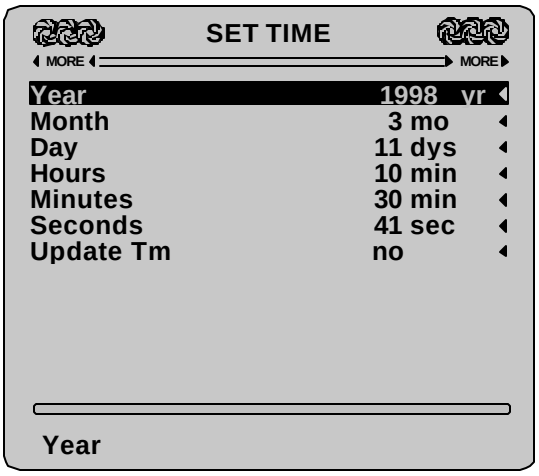
User Pswd T.O. User Password Time Out sets the length of time delay after any key press before the Electrospeed GCS sets the user password back to zero.

Security Jmp St Security Jumper Status shows whether the Centrilift service man 's security jumper has been installed.



CURRENT TIME

Current Time This screen displays the present settings of the battery backed, real time clock operating in the GCS system. The primary purpose of the clock is to be able to record the dates and times for the Shutdown History and the data logging functions. The GCS real time clock is YEAR 2000 compliant, no time or date related problems will occur.
Note the Invalid Time Alarm setpoint. This alarm enunciates the fact that the real time clock does not contain valid data. If this alarm is active, use the SET TIME screen to enter the correct time and date and this alarm will become inactive.

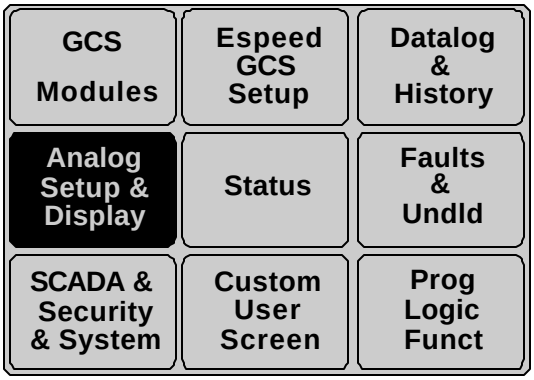


SET TIME

Set Time This screen allows access to the time and date settings of the GCS system real time clock. This clock should be reset to the current time and date if the onboard battery has been changed, or disconnected for any reason.

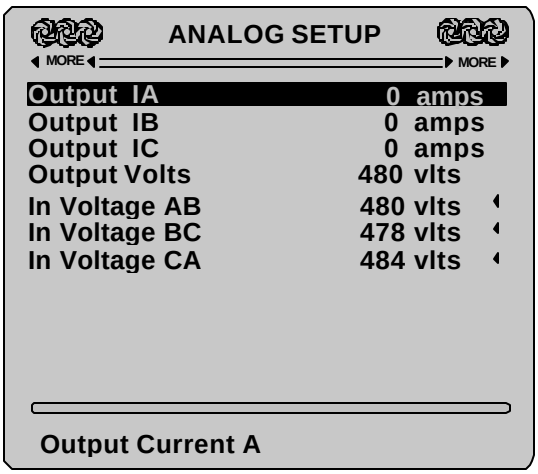
Year The current year, ranges from 1900 to 2035
Month The current month, ranges from 1 to 12
Day The current day, ranges from 1 to 31
Hours The current time in hours, ranges 0 to 23
Minutes The current time in minutes, ranges 0 to 59
Seconds The current time in seconds, ranges 0 to 59

Update Tm When all of the time variables have been set to the current time, set this parameter to "YES " to save the new time and update the GCS system clock.



ANALOG SETUP & DISPLAY

The Analog Setup screen permits display and adjustment of the output current and voltage readings as well as the input voltages.



ANALOG SETUP

Output IA Output Current Phase A is the present, scaled value of the output electrical current on phase A of the polyphase power system.

Output IB Output Current Phase B is the present, scaled value of the output electrical current on phase B of the polyphase power system.

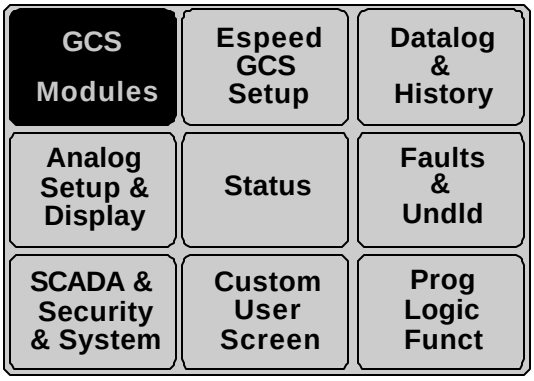
Output IC Output Current Phase C is the present, scaled value of the output electrical current on phase C of the polyphase power system.

Output Voltage Output voltage displays the present value of the AC voltage available on the output terminals of the drive.

In Voltage AB Input Voltage Ø AB displays the phase to phase AC, RMS voltage level present across the A and B phase input terminals of the drive. These voltage readings can be scaled.

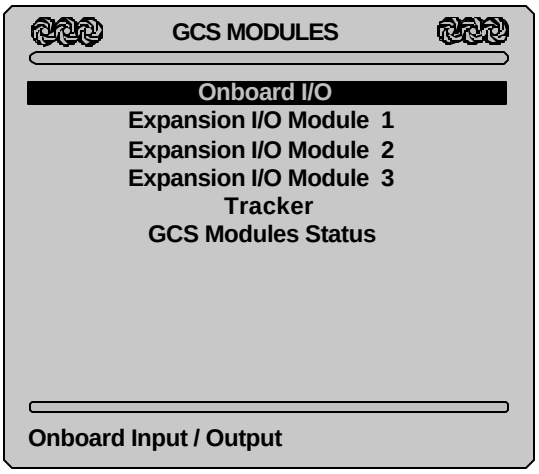
In Voltage BC Input Voltage Ø BC displays the phase to phase AC, RMS voltage level present across the B and C phase input terminals of the drive. These voltage readings can be scaled.

In Voltage CA Input Voltage Ø CA displays the phase to phase AC, RMS voltage level present across the C and A phase input terminals of the drive. These voltage readings can be scaled.



GCS MODULES

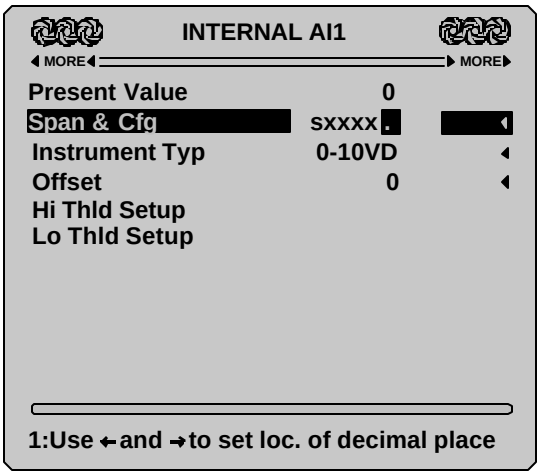
The GCS MODULES screen allows access to the sub menus providing control of the setup parameters dealing with all Input /Output Modules, both built-in (onboard), optional, externally mounted expansion cards as well as the Tracker sub-menu. To select the onboard I/O setup and calibration screens, use the arrow keys to move the cursor bar over the onboard I/O menu item as shown below and press the ENTER key. The GCS will display the first of the calibration screens for the onboard I/O. To access the other setup screens, move the cursor over the menu item desired and press ENTER to display that screen.

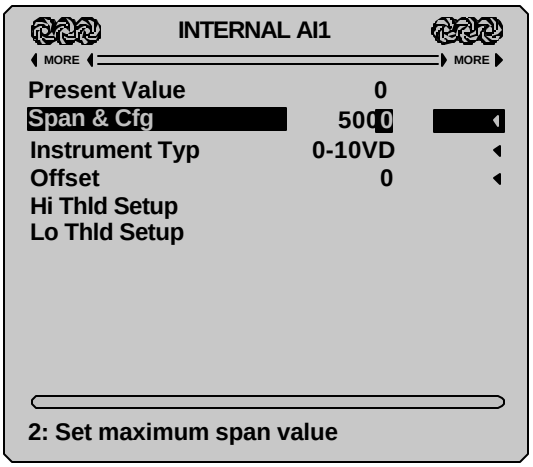


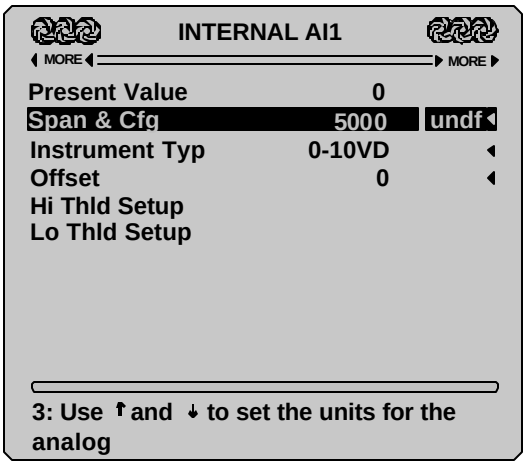
ONBOARD I/O

The Onboard Input /Output menu provides access to the setup screens for the built-in I/O. These consist of two 0-10 volt DC analog inputs and three digital (status) inputs. The first screen shown will normally be the INTERNAL AI1, as shown in the next illustration.

INTERNAL ANALOG INPUT 1







This menu screen provides access to all the parameters related to the 0-10 VDC signal applied to Analog input terminal #1

Present Value The number displayed represents the current scaled value of the analog signal present on analog input terminal #1.

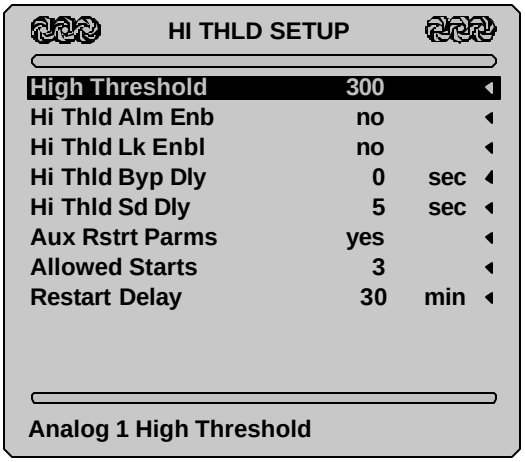
Span & Cfg This parameter is used to select the analog input's span (maximum reading at maximum input), the location of the decimal point (divide by 10, 100 or 1000) and the engineering units (psi, amps, volts etc.) Move the cursor to highlight this parameter and press the ENTER key. The highlight cursor will change to appear like the first illustration at left. At this point, use the left/right arrow keys to move the decimal point left or right as required, then press ENTER again. The highlight cursor will change to show a screen similar to the center illustration at left and displays the maximum span of the analog input. Use the up/down or left/right arrow keys to adjust the span to the required value, then press ENTER again. The cursor will change once more and allow the user to select engineering units applicable to the analog input. At this point use the up/down arrow keys to scroll through the available engineering units until the desired one appears, then press ENTER to finalize the configuration. The illustration at bottom left shows the analog 1 units being displayed as "undf" or undefined.

Instrument Typ Allows selection of the type of signal connected to the analog input. The instrument types are 0-10Vdc, 0-5Vdc, 4-20mA, 10-50mA. To use the current loop type, an appropriate size of resistor should be connected in parallel with the analog input to convert the signal into a voltage. For example, use a 500-ohm resistor to convert 4-20mA into 2-10 Vdc. Then set the type to 4-20mA, and the controller will perform the offset calculations required.

Offset Use this parameter to add or subtract an offset value from the present scaled analog value.

Hi Thld Setup This menu accesses the parameters associated with a high threshold alarm on analog input 1. Highlight this item and press ENTER to access the subsequent menu.

Lo Thld Setup This menu accesses the parameters associated with a low threshold alarm on analog input 1. Highlight this item and press ENTER to access the subsequent menu.



HIGH THRESHOLD SETUP

High Threshold Sets the upper threshold of analog input #1 value that if exceeded, will cause the motor to shutdown.

Hi Thld Alm Enb High Threshold Alarm Enable controls whether the GCS controller will shutdown the motor when the "Present Value" of analog input #1 exceeds the "High Threshold value".

Hi Thld Lk Enbl High Threshold Lockout Enabled controls whether the controller will "lockout" and prevent further automatic restart attempts when the GCS shuts down the motor because of a High Threshold alarm.

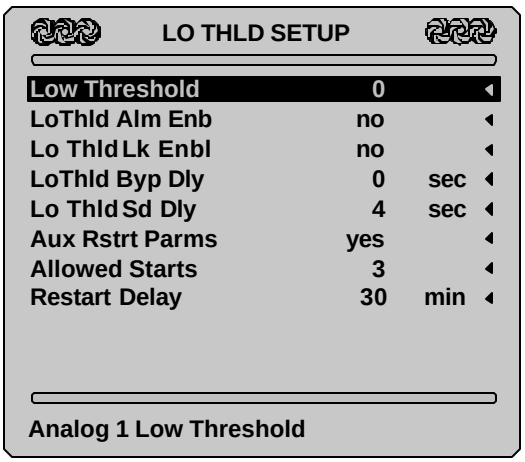
Hi Thld Byp Dly High Threshold Bypass Delay sets the number of seconds that the GCS controller will ignore a High Threshold alarm condition that is present at start-up time.

Hi Thld Sd Dly High Threshold Shutdown Delay sets the number of seconds that the controller will ignore a High Threshold alarm condition that exists while the motor is running but only after the High Threshold Bypass Delay timer has expired.

Aux Rstrt Parms When set to "YES ", the Auxiliary Restart Parameters setpoint causes the Electrospeed controller to use the restart parameters listed below when it shuts down due to an Analog Input 1 High Threshold alarm. If this parameter is set to "NO", the controller will use the global restart parameters when performing an automatic restart. The global restart parameters are set from the Electrospeed GCS setup menus.

Allowed Starts Allowed starts controls how many automatic restarts will be allowed when the controller has shutdown due to an Analog Input 1 High Threshold alarm and the Aux Rstrt Parms has been set to "YES ".

Restart Delay Restart Delay controls the length of time the controller will wait before attempting to restart the motor when it was shut down due to an Analog Input 1 High Threshold alarm and the Aux Rstrt Parms has been set to "YES ".



LOW THRESHOLD SETUP

Low Threshold Sets the lower threshold of analog input value that if exceeded, will cause the motor to shutdown.

Lo Thld Alm Enb Low Threshold Alarm Enable controls whether the GCS controller will shutdown the motor when the Present Value falls below the Low Threshold value.

Lo Thld Lk Enbl Low Threshold Lockout Enabled controls whether the controller will "lockout" and prevent further automatic restart attempts when the GCS shuts down the motor because of a Low Threshold alarm.

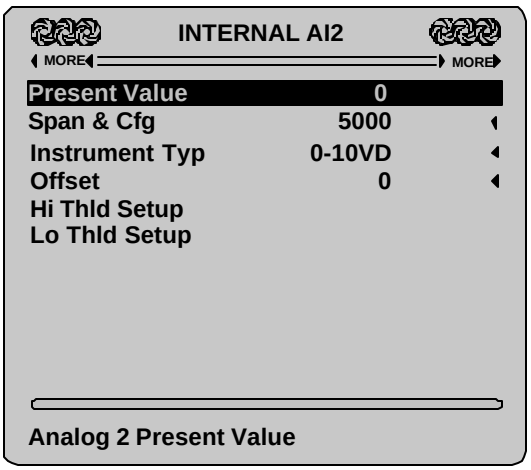
Lo Thld Byp Dly Low Threshold Bypass Delay sets the number of seconds that the GCS controller will ignore a Low Threshold alarm condition that is present at start-up.

Lo Thld Sd Dly Low Threshold Shutdown Delay sets the number of seconds that the controller will ignore a Low Threshold alarm condition that exists anytime the motor is running but only after the Low Threshold Bypass Delay has expired.

Aux Rstrt Parms When set to "YES ", the Auxiliary Restart Parameters setpoint causes the Electrospeed controller to use the restart parameters listed below when it shuts down due to an Analog Input 1 Low Threshold alarm. If this parameter is set to "NO", the controller will use the global restart parameters when performing an automatic restart. The global restart parameters are set from the Electrospeed GCS setup menus.

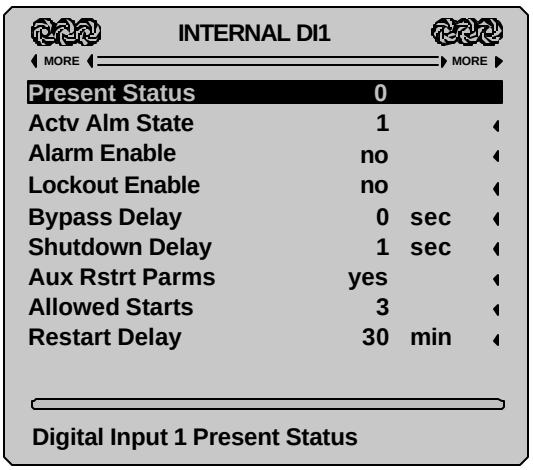
Allowed Starts Allowed starts controls how many automatic restarts will be allowed when the controller has shutdown due to an Analog Input 1 Low Threshold alarm and the Aux Rstrt Parms has been set to "YES ".

Restart Delay Restart Delay controls the length of time the controller will wait before attempting to restart the motor when it was shut down due to an Analog Input 1 Low Threshold alarm and the Aux Rstrt Parms has been set to "YES ".



INTERNAL ANALOG INPUT 2

This setup and calibration screen is accessed by pressing the right arrow key while displaying the screen for INTERNAL ANALOG INPUT 1. This second analog input is calibrated and operates in exactly the same way as INTERNAL ANALOG INPUT 1, however, all of the readings and setpoints are based on the analog signal connected to the analog #2 input terminal. Configuration of the settings is more thoroughly explained in the preceding section, INTERNAL ANALOG INPUT 1.



INTERNAL DIGITAL INPUT 1

This menu screen provides access to all the parameters related to the digital status (on / off) signal applied to digital input terminal #1. The digital inputs are activated by shorting the input terminal to the Digital Common Ground terminal provided on the same terminal block.
If the External HOA parameter is enabled, Digital Input 1 is dedicated to function as a START push-button switch and is unavailable for general-purpose use.

Present Status The number displayed to the right of this label represents the current condition of the status signal present on digital input terminal #1. An open circuit on terminal 1, produces a status value of 1 (one). If the switch or sensor connected between the input and Common Ground is closed, the status value of digital input becomes 0 (zero). This is the factory default active alarm state and can also be classified as Open to Alarm.

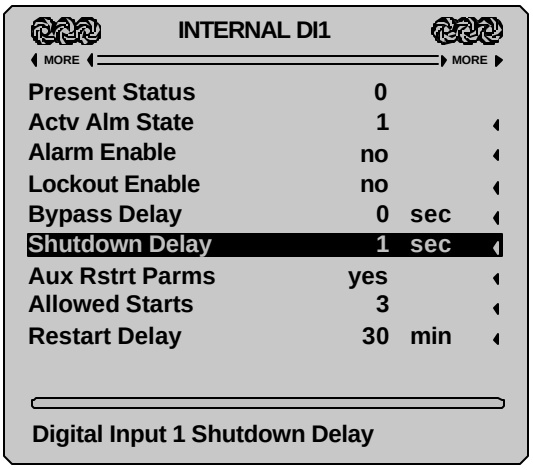
Active Alarm ST The Active Alarm State parameter allows the user to select whether this digital input is considered in the alarm state when the input is one or zero. Set this variable to whichever digital input state (one or zero) will be considered the alarm state. When the Present Value of the digital input matches the value of this setpoint, the alarm is activated and if enabled, will cause a shutdown.

Alarm Enable Controls whether the GCS controller will shutdown the motor when the Present Status of the digital input equals the Active Alarm State.

Lockout Enabled Controls whether the controller will "lockout" and prevent further automatic restart attempts

when the GCS shuts down the motor because of a Digital input 1 alarm.

Bypass Delay Sets the number of seconds that the GCS controller will ignore a Digital Input 1 alarm condition that is present at start-up time.



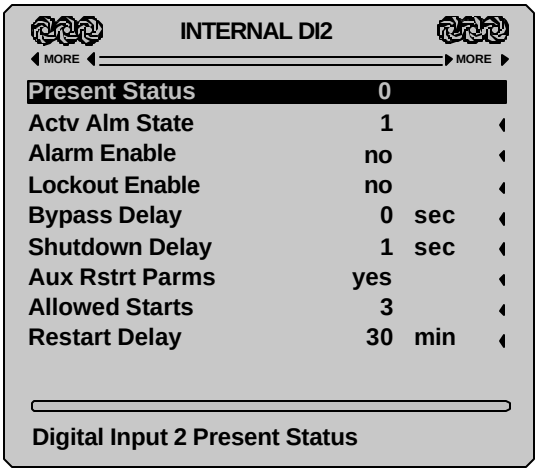
Shutdown Delay Sets the number of seconds that the controller will ignore a Digital input 1 alarm condition that exists while the motor is running, but only after the digital input 1 Bypass Delay timer has expired.

Aux Rstrt Parms When set to “YES “, the Auxiliary Restart Parameters setpoint causes the Electrospeed controller to use the restart parameters listed below when it shuts down due to an Internal Digital Input 1 alarm. If this parameter is set to “NO”, the controller will use the global restart parameters when performing an automatic restart. The global restart parameters are set from the Espeed GCS setup menus.

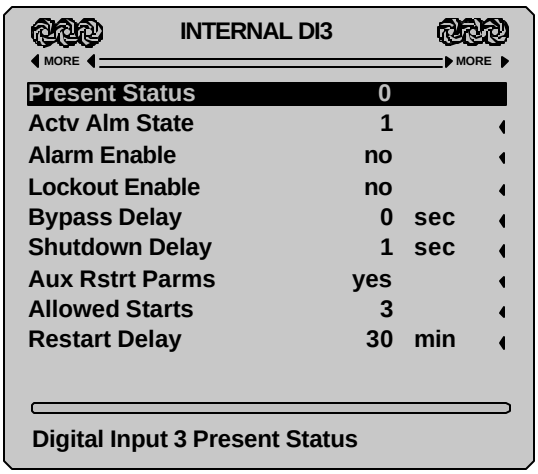
Allowed Starts Allowed starts controls how many automatic restarts will be allowed when the controller has shutdown due to an Internal Digital Input 1 alarm and the Aux Rstrt Parms has been set to “YES “.

Restart Delay Restart Delay controls the length of time the controller will wait before attempting to restart the motor when it was shut down due to an Internal Digital Input 1 alarm and the Aux Rstrt Parms has been set to “YES “.

INTERNAL DIGITAL INPUT 2

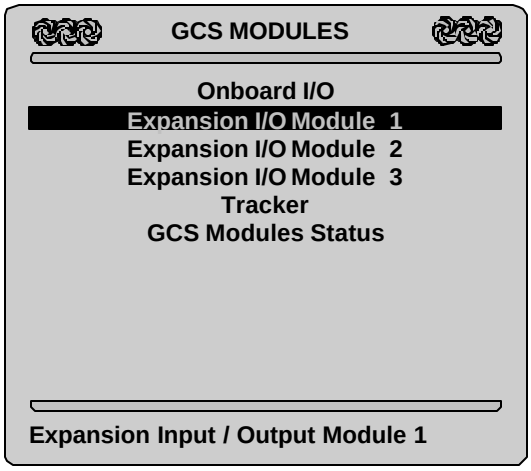


This menu screen provides access to all the parameters related to the digital status (on / off) signal applied to digital input terminal #2. The digital inputs are activated by shorting the input terminal to the Digital Common Ground terminal provided on the same terminal block.
If the External HOA parameter is enabled, Digital Input 2 and 3 are dedicated to this function and are unavailable for general-purpose use. All parameters function in the same manner as Digital Input #1. Refer to that section for details.



INTERNAL DIGITAL INPUT 3

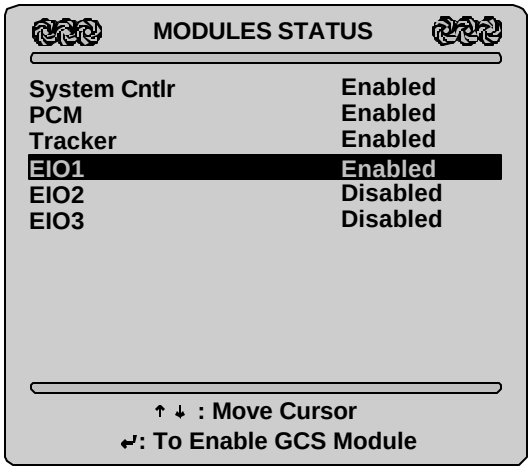
This menu screen provides access to all the parameters related to the digital status (on / off) signal applied to digital input terminal #3. The digital inputs are activated by shorting the input terminal to the Digital Common Ground terminal provided on the same terminal block. If the External HOA parameter is enabled, Digital Input 2 and 3 are dedicated to this function and are unavailable for general-purpose use. All parameters function in the same manner as Digital Input #1. Refer to that section for details.



EXPANSION I/O MODULE 1
EXPANSION I/O MODULE 2
EXPANSION I/O MODULE 3
TRACKER

These menus provide access to the parameters related to installed modules such as expansion input/output cards and the Tracker ™ downhole sensor. Please view menu and parameter descriptions in the operators manual provided with the applicable module.

GCS Modules Status The GCS Modules Status screen allows the user to enable expansion modules connected to the CITIBus communication bus.



MODULES STATUS

This menu screen shows which of the available expansion modules are enabled to communicate on the CITIBus network. Move the highlighting cursor to the available items and press ENTER to enable that module.

System Cntlr System controller is always enabled.

PCM Power Conversion Module is enabled when configured as Variable speed controller.

Tracker Enabled if a Tracker GCS module is attached.

EIO1, EIO2, EIO3 Expansion Input / Output modules 1, 2 and 3 can be added and enabled.

EXPANSION AND OPTIONS

The Electrospeed GCS controller can be interfaced to a variety of expansion modules or optional sensors. The information described herein is of a very brief nature. If further data is required, please refer to the documentation supplied with the individual devices.

Tracker GCS Downhole Sensor
The Tracker GCS downhole sensor package is available as a stand-alone GCS compatible unit or as an optional expansion module for the Electrospeed GCS drive. When utilized as an expansion device, the Tracker will be configured and its data viewed on the same graphic display unit used for the drive. The Tracker system unit is installed in the Electrospeed enclosure and is integrated into the Graphic Control System by simply connecting the CITIBus data cable from the drive, to the Tracker and then finally to the graphic display unit. In this way, the drive is capable of reading and using the downhole measurement provided by the Tracker.

Vortex Communication Interface Model VCI-142
The VCI-142 is a communication interface device designed to convert the Electrospeed GCS's RS-232 serial data port into a two wire half-duplex RS-485 port or a four wire full-duplex RS-422 port. Either of the two configurations can be interfaced to a multi-drop cable bus system since each transmitter is driven to a high impedance, standby state when the device is inactive. The VCI-142 uses the built in RS-232 port for data access and is powered by the 120VAC control voltage available within the VSD.

Centrilift PHD Sensor package
The PHD sensor package provides a 0-10VDC variable analog signal proportional to the bottom hole pressure of the well that it is installed onto. This 0-10VDC signal is then fed directly into one of the two analog input ports that are standard equipment on the Electrospeed GCS.

Third Party Equipment
In general, any third party sensors, measurement or detection devices can be used in conjunction with the Electrospeed GCS if they produce a measurable analog output signal or a dry contact status output signal. In the case of analog signals, the output should provide 0-10VDC or a 4-20mA and be self-powered. If a 4-20mA gauge is to be used, it must produce a signal with enough capability to drive a 500 ohm load that will convert the current into a 2 - 10 VDC signal. Then, select the instrument type of 4-20mA and the Electrospeed GCS will

zero the 2VDC signal state and use the remaining range in the scaling process.

MAINTENANCE

Only minor adjustment should be necessary on initial start-up, depending on the application. In addition to setting these, some common sense maintenance need be followed.

Operating Temperatures:

NEMA 1 (IP33) Enclosure: Keep unit located away from other equipment having a high ambient temperature. Air flow across the heat sinks must not be restricted.

NEMA 3 (IP54) Enclosure: In extremely high ambient temperatures it may be necessary to place a sun shade over the unit to keep within operating temperature range.

Keep Unit Clean:
As with any electronic equipment, cleanliness will enhance operating life.

Keep Connections Tight:
The equipment should be kept away from high vibration areas that could loosen connections or cause chafing of wires. All interconnections should be re-tightened at initial start-up and at least every six months.

Reform DC Electrolytic Capacitors: after six months in storage.

External Cooling Fan (NEMA 3 Only): Oil every six months with SAE20.

For more information refer to the GCS maintenance and troubleshooting manual.

TROUBLESHOOTING

IMPORTANT SAFEGUARDS
Personnel familiar with its operation and application must perform all work on this controller.

WARNING

The following warnings must be heeded. Failure to do so could result in personal injury!

- Lethal voltages are present within the cabinet when input power is applied.
- External voltages could be present in the area of the customer termination area even with all power removed from the drive input.
- Always check for voltages across the DC Bus before performing any troubleshooting, part replacement or removal. Lethal voltages (up to 700V DC) may be present under certain conditions.
- To prevent component damage, do not remove any cable connectors without removing all power to the controller AND allow sufficient time to discharge any supply capacitors. Usually one minute is sufficient .

For more information refer to the GCS maintenance and troubleshooting manual.

Appendix A : SPECIFICATIONS & RATINGS

SPECIFICATIONS

Output Frequency:	10 to 120 Hz. at 480V AC
Output Voltage at 60 Hz.:	40 to 480V AC
Start Frequency:	3 to 20 Hz.
Sync Delay Time:	0 to 60 sec.
High Speed Clamp:	40 to 120 Hz.
Frequency Resolution:	± .1 Hz.
Volts/Hertz:	.7 - 10 Volts
Low Speed Clamp:	5 to 90 Hz.
Voltage Boost:	0 to 200V AC
Voltage Boost Sync:	0 to 200V AC
Instantaneous Over Current (IOT):	170% of Full Load Rating
Current Limit:	0 to 150% of VSC Rating
Current Limit Sync:	0 to 150% of VSC Rating
Maximum Overload current:	0 to 150% of VSC Rating for Variable Torque 0 to 200% of VSC Rating for Constant Torque
Voltage Clamp:	240 to 550V AC
Acceleration Time:	2 to 200 Sec.
Deceleration Time:	2 to 200 Sec.
Slip Compensation:	0 to 7.5%
Control Power:	24V DC
Efficiency:	> 98% at Rated Load
Power Factor:	.96 at Full Speed

RATINGS

Input Voltage: (Standard):	380 to 480V AC + 5%, -20%, 50/60 Hz
Frequency:	± 2 Hz
Input Current:	See Appendix E:
Output Ratings:	See Appendix E:
Operating Temperature:	
NEMA 1:	(IP 33): 0 to 40° C (32 to 104° F)
NEMA 3:	(IP 54): 0 to 50° C (32 to 122° F) w/Heater: -40 to 50° C (-40 to 122° F)
Storage Temperature:	-50 to 70° C (-58 to 158° F)
Humidity:	
NEMA 1 (IP 33):	95% Non-Condensing
NEMA 3 (IP 54):	Suitable for use outdoors in all climatic conditions.
Elevation:	To 5000 Ft. without de-rating
Weight:	See Appendix H
Dimensions:	See Appendix H

APPENDIX B: START-UP WORKSHEET

Customer : _____ Date: _____

Well Number: _____ Drive S/N: _____

1: Motor Voltage: _____ Amps: _____ Cable Size: _____ Length: _____

2: Desired Operating Frequency Minimum: _____ Maximum: _____

3: Maximum Volts Available (Input Voltage): _____

4: Secondary Voltage @ Maximum Hertz: =

$$\frac{\text{Motor Voltage} \_\_\_\_ \times \text{Max. Hz.} \_\_\_\_}{60 \text{ Hz.}} + \text{Cable Drop} \_\_\_\_ = \_\_\_\_$$

5: Secondary Voltage Taps Selected: _____

6: Transformer Ratio: =

$$\frac{\text{Secondary Voltage Taps Selected} \_\_\_\_}{\text{Transformer Primary (480)}} = \_\_\_\_$$

7: Secondary Voltage @ 60 Hertz:=

$$\frac{\text{(from line 4) Secondary Voltage @ Max. Hertz} \_\_\_\_ \times 60}{\text{Maximum Hertz} \_\_\_\_} = \_\_\_\_$$

8: Drive Volts @ 60 Hertz: =

$$\frac{\text{(from line 7) Secondary Voltage @ 60 Hertz} \_\_\_\_}{\text{Transformer Ratio} \_\_\_\_} = \_\_\_\_$$

9: Required KVA @ Max. Hertz: =

$$\frac{\text{Surface Voltage} \_\_\_\_ \times \text{Motor Nameplate Amps} \_\_\_\_ \times 1.73}{1000} = \_\_\_\_$$

10: Controller sizing: = Motor Nameplate Amps X Transformer Ratio = _____

(Select a drive Model with a continuous current rating => than this calculation)
(Refer to Appendix A: Specification and Sizes)

11: V-Clamp: =

$$\frac{\text{(from line 8) Drive Volts @ 60 Hertz} \times \text{Max Hz}}{60} = \_\_\_\_$$

APPENDIX C: INSTALLATION/SERVICE RECORD

Area _____ **District** _____

Startup____ **Service**____ **Restart**____ **Report**

Customer _____ County / Province _____ State / Country _____

Facility /Field _____ Unit / Lease _____ No_____ City _____

VSC S/N: _____ Model _____ Amps _____ KVA_____ Software Rev:PCM_____

Motor Mfg Volts Amps Hp Service SYSCON_____ DISPLAY_____

Cable Size_____ Ft_____ Volts/Ft_____ Temp Factor _____ Cable _____

Pump Mfg_____ Model_____ Series_____ Stages_____

Intake (Rotary, Rev-Flow, Std) Min Hz_____ BPD_____ Max Hz_____ BPD_____

Check Valve Jap Setting Ft Bottom Hole Temp F. deg

Xfrm S/N Voltage Ratio Taps 1 2 Delta WYE

Drive Input Volts Unloaded
a/b a/c b/c

Drive Input Volts to Ground
a_____ b_____ c_____

Drive Input Volts Loaded
a/b a/c b/c

Drive Output Volts
@ Hz_____ a/b_____ a/c_____
@ Hz_____ a/b_____ a/c_____

Surface Voltage Phase to Ground
a) b) c)

Drive Input Amps
@ Hz_____ a)_____ b)_____ c)_____
@ Hz_____ a)_____ b)_____ c)_____

Drive Output Amps
@ Hz a) b) c)
@ Hz_____ a)_____ b)_____ c)_____

Down Hole Motor Amps
@ Hz_____ a)_____ b)_____ c)_____
@ Hz a) b) c)

Motor & Cable Ohms Phase to Ground
a_____ b_____c_____

Motor & Cable Ohms Phase to Phase
a/b_____ a/c_____ b/c_____

Setup or Operating Parameters

_____Overload Amps	_____Volts @60Hz	_____Sync Delay	_____Low Speed Clamp
_____Overload Time	_____Start Frequency	_____Hi Speed Clamp	_____VBoost
_____I Limit	_____V Boost Sync	_____Accel Time	_____Reg.Gain%
_____I Limit Sync	_____V Clamp	_____Decel Time	_____Slip Comp%
_____Fault Restarts	_____Underload Amps	_____Control Setpoint	_____Aux. Restart
_____Restart Delay	_____Jog Frequency	_____PHD Zero	_____ PHD Span
_____Fault Reset	_____Underload Restarts		_____Frequency Avoid
_____Set Speed(Hz)	_____UL Trip Delay	_____Output Rotation	
_____Run Speed(Hz)	_____Mode	_____Control Signal	_____Analog 1 or 2
Bypass LSTrip Delay	LSTrip Delay	LSTrip Enable	LSTrip Lockout
_____UL Bypass Delay	_____UL Delay	_____UL Enable	_____UL Lockout
DI1 Bypass Delay	DI1 Delay	DI1 Enable	DI1 Lockout
_____DI2 Bypass Delay	_____DI2 Delay	_____DI2 Enable	_____DI2 Lockout
OL Bypass Delay	OL Delay	OL Enable	OL Lockout
_____Wait for Restart Delay			

Comments / Observations :_____

_____

_____

_____

Job Started: **Job Completed:** **Serviced**

APPENDIX D: CABLE SIZING

Fuse Size (Amps)	Cable Sizes Per Phase	Lug Size per Phase Input	Lug Size per Phase Output
100	# 2 AWG	1ea. 14-1/0	1ea. 6-250 MCM
200	# 3/0 AWG	1ea. 4-300 MCM	1ea. 6-250 MCM
300	2-2/0 AWG	1ea. 4-250 MCM & 1ea. 2/0-500 MCM	2ea. 6-250 MCM
400	2-4/0 AWG	1ea. 4-250 MCM & 1ea. 2/0-500 MCM	2ea. 6-250 MCM
500	2-300 MCM	3ea. 250-500 MCM	3ea. 3/0-400 MCM
600	2-400 MCM	3ea. 250-500 MCM	3ea. 3/0-400 MCM
700	3-350 MCM	3ea. 250-500 MCM	3ea. 3/0-400 MCM
800	3-400 MCM	3ea. 250-500 MCM	3ea. 3/0-400 MCM
2 - 500	4-300 MCM	6ea. 250-600 MCM	6ea. 250-600 MCM
2 - 600	4-400 MCM	6ea. 250-600 MCM	6ea. 250-600 MCM
2 - 700	6-350 MCM	6ea. 250-600 MCM	6ea. 250-600 MCM
2 - 800	6-400 MCM	6ea. 250-600 MCM	6ea. 250-600 MCM
Minimum Size Conductors for Equipment as recommended by the USA National Electric Code. Must meet local and other applicable codes for actual sizes.			

Controller Recommended Cable Sizes

Input Fuse per Phase (Amps)	Copper Wire Size No.	Aluminum or Copper Clad Aluminum Wire Size No.
100	# 8 AWG	# 6 AWG
200	# 6 AWG	# 4 AWG
300	# 4 AWG	# 2 AWG
400	# 3 AWG	# 1 AWG
500	# 2 AWG	# 1/0 AWG
600	# 1 AWG	# 2/0 AWG
700	# 1/0 AWG	# 3/0 AWG
800	# 1/0 AWG	# 3/0 AWG
2 - 500	# 2/0 AWG	# 4/0 AWG
2 - 600	# 3/0 AWG	# 250 MCM
2 - 700	# 4/0 AWG	# 300 MCM
2 - 800	# 4/0 AWG	# 350 MCM
Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment as recommended by the USA National Electric Code. Must meet local and other applicable codes for actual sizes.		

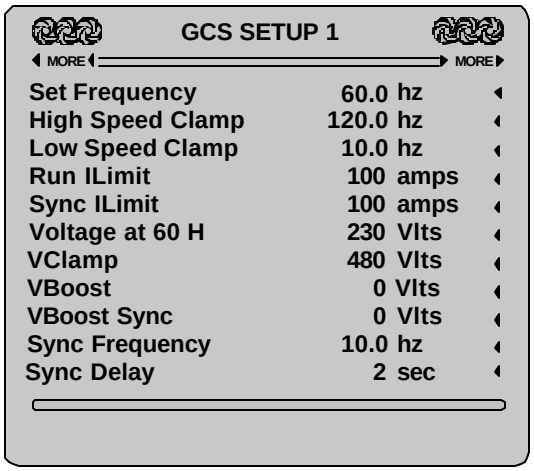
Controller Recommended Grounding Cable

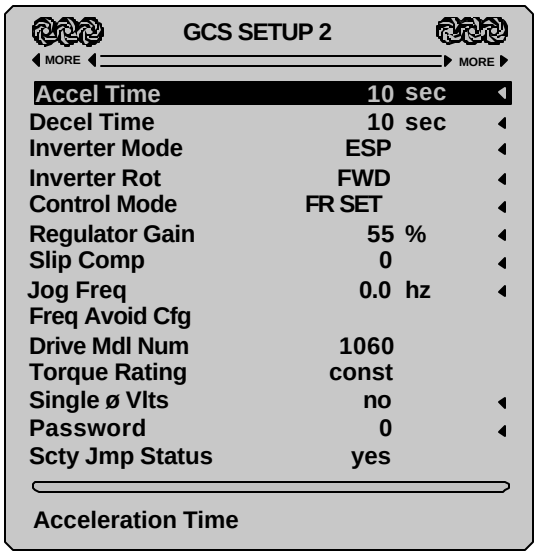
APPENDIX E: VARIABLE TORQUE VSC RATINGS

Output Ratings @ 480VAC / 400VAC					Input Ratings Amps	
Model	KVA 480/400	Continuos Current RMS Amps	Overload Current 60 Sec.	Start Current 7 Sec.	Fuse Rating	Input Current
1060 or 2060-VT	66 / 52	79	95	119	100	83
1075 or 2075-VT	83 / 66	100	120	150	200	105
1100 or 2100-VT	111 / 88	133	160	200	200	140
1125 or 2125-VT	130 / 103	156	187	234	200	164
2150-VT	163 / 129	196	235	294	300	206
2200-VT	200 / 159	241	289	362	300	253
2250-VT	260 / 206	313	376	470	400	329
4300-VT	325 / 257	391	469	587	500	411
4350-VT	390 / 308	469	563	704	600	492
4400-VT	454 / 359	546	655	819	700	573
4500-VT	519 / 411	624	749	936	800	655
8600-VT	624 / 494	750	900	1125	500x2	788
8700-VT	748 / 592	900	1080	1350	600x2	945
8800-VT	873 / 691	1050	1260	1575	700x2	1103
8900-VT	1000 / 792	1203	1444	1805	800x2	1263

NOTE: When applying variable speed controllers to constant torque loads, the continuous output current and output KVA are de-rated by 20%. The Overload and Start currents remain the same. The model numbers listed here do not include the enclosure identifier. (i.e. 2200-1VT or 2200-3VT)

APPENDIX F: BASIC CONFIGURATION

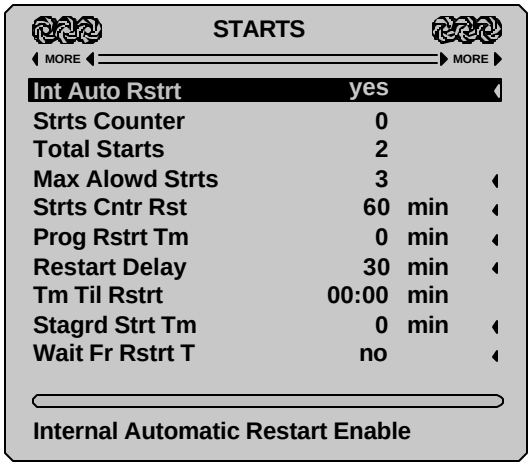




The following procedure will set the majority of the parameters required for actual start-up of the GCS controller in normal submersible pump operating conditions. Perform the “FORMING CAPACITORS” steps only if the unit has not been operating for 6 months or more. Please ensure safety precautions are observed.

1. Turn on the Main Input Power Switch, then press the **STOP** key on the Keypad.
2. Set **Frequency** to 60 Hz .
3. Set **High Speed Clamp** to hertz required for application.
4. Set **Low Speed Clamp** to hertz required for application.
5. Set **Run ILimit** to motor nameplate amps X transformer ratio X 105%.
1. Set **Sync ILimit** to motor nameplate amps X transformer ratio X 125%.
2. Set **Voltage at 60Hz** to the value calculated in the START-UP worksheet.
3. Set **VClamp** to value of incoming voltage, but no greater than 480 volts.
4. Set **VBoost** to zero
5. Set **VBoost Sync** to zero.
6. Set **Sync Frequency** to 10 Hz.
1. Set **Sync Delay** to 2 seconds.
2. Set **Accel Time** to 10 seconds.
3. Set **Decel Time** to 10 seconds.
4. Set **Inverter Rotation** to FORWARD or “FWD”.
5. Set **Regulator Gain** to 70 %.
6. Set **Slip Comp** to zero.
7. Set **Frequency Avoidance** frequencies to zero.
8. Set **Control Mode** to Frequency Setpoint (FR SET)
9. Set **Max Alowd Strts** to 5.
10. Set **Strts Cntr Rst** delay to 30 minutes.
11. Set **Rstrt Dly** to 30 minutes.
12. Set **OVERLOAD** setpoint to motor nameplate amps X transformer ratio X 120%.
13. Set **OVERLOAD SHUTDOWN DELAY** to 5 seconds
14. Set **UNDERLOAD Setpoint** to ZERO.
15. Set **UNDERLOAD Shutdown Delay** to 30 seconds.
16. Check and/or set CLOCK to current time and date.
17. If required, perform the steps in the following section to **FORM CAPACITORS** or proceed to **NO-LOAD SETUP**.

FOR INITIAL START-UP OR TROUBLESHOOTING IT IS RECOMMENDED, WHERE PRACTICAL, THAT THE LOAD BE DISCONNECTED, AND THE VSC OPERATED NO-LOAD TO VERIFY CORRECT OPERATION.

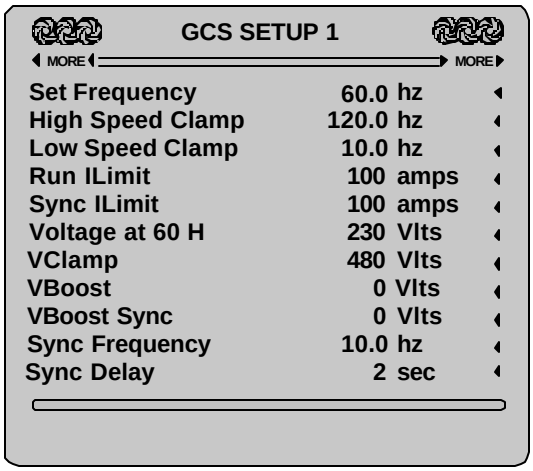


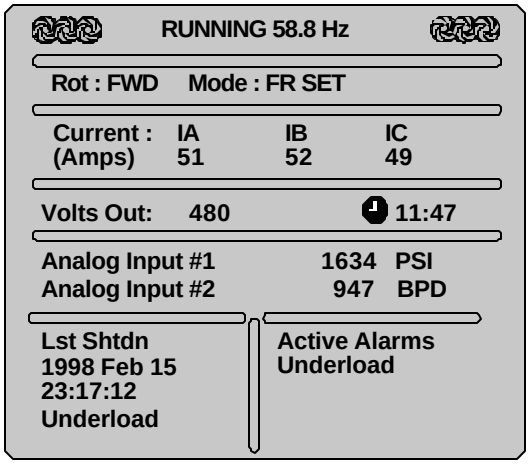
FORMING CAPACITORS

Perform these steps only if the unit has not been operating within 6 months.

1. Perform the preceding steps for BASIC CONFIGURATION.
2. Set **Run I LIMIT** to the maximum value.
3. Set **SYNC I LIMIT** to the maximum value.
4. Set **VOLTS AT 60HZ** to 230 volts.
5. Set **OVERLOAD SETPOINT** to maximum rating of controller
6. Press **START** button and confirm the controller ramps up to 60 Hz.
7. Monitor output volts, at 60 Hertz drive should have 230 volts out.
8. Increase **VOLTS AT 60 HZ**. in 50 volt increments with five minute pauses between each increase until maximum output voltage is reached.
9. Press **STOP** to shutdown controller.

APPENDIX G: START UP





If the GCS controller has not been started or used in this application before, the steps in APPENDIX F: BASIC CONFIGURATION should be performed before these NO-LOAD or START-UP steps are attempted.

NO LOAD SETUP

1. Disconnect down hole cable at junction box.
2. Set **Voltage at 60Hz** as per start-up worksheet.
3. Ensure that **OVERLOAD** setpoint equals motor nameplate amps X transformer ratio X 120%.
4. Ensure that **Run ILimit** equals motor nameplate amps X transformer ratio X 105%.
5. Ensure that **Sync ILimit** equals motor nameplate amps X transformer ratio X 125%.
6. Turn off the Main Input Power Switch.
7. Connect a phase sequence meter to output of the controller to the point nearest the well head to confirm proper phase rotation.
8. Turn on the Main Input Power Switch.
1. Press **START** button and confirm correct phase sequence, then stop the controller.
2. Turn off the Main Input Power Switch and disconnect phase sequence meter

START-UP

1. Connect down hole cable to junction box.
1. From **MAIN MENU**, select and display **STATUS** screen.
2. Press **START** button and confirm that output frequency ramps up to set speed or 60 Hz.
3. Confirm correct **Voltage at 60Hz** output voltage of controller on **STATUS** screen.
4. Set **FREQUENCY** to minimum speed per start-up worksheet.
5. Set **UNDERLOAD** setpoint to 10% less than lowest output phase current while running at minimum hertz. Record on start-up sheet.
6. Set **FREQUENCY** to desired operating speed.

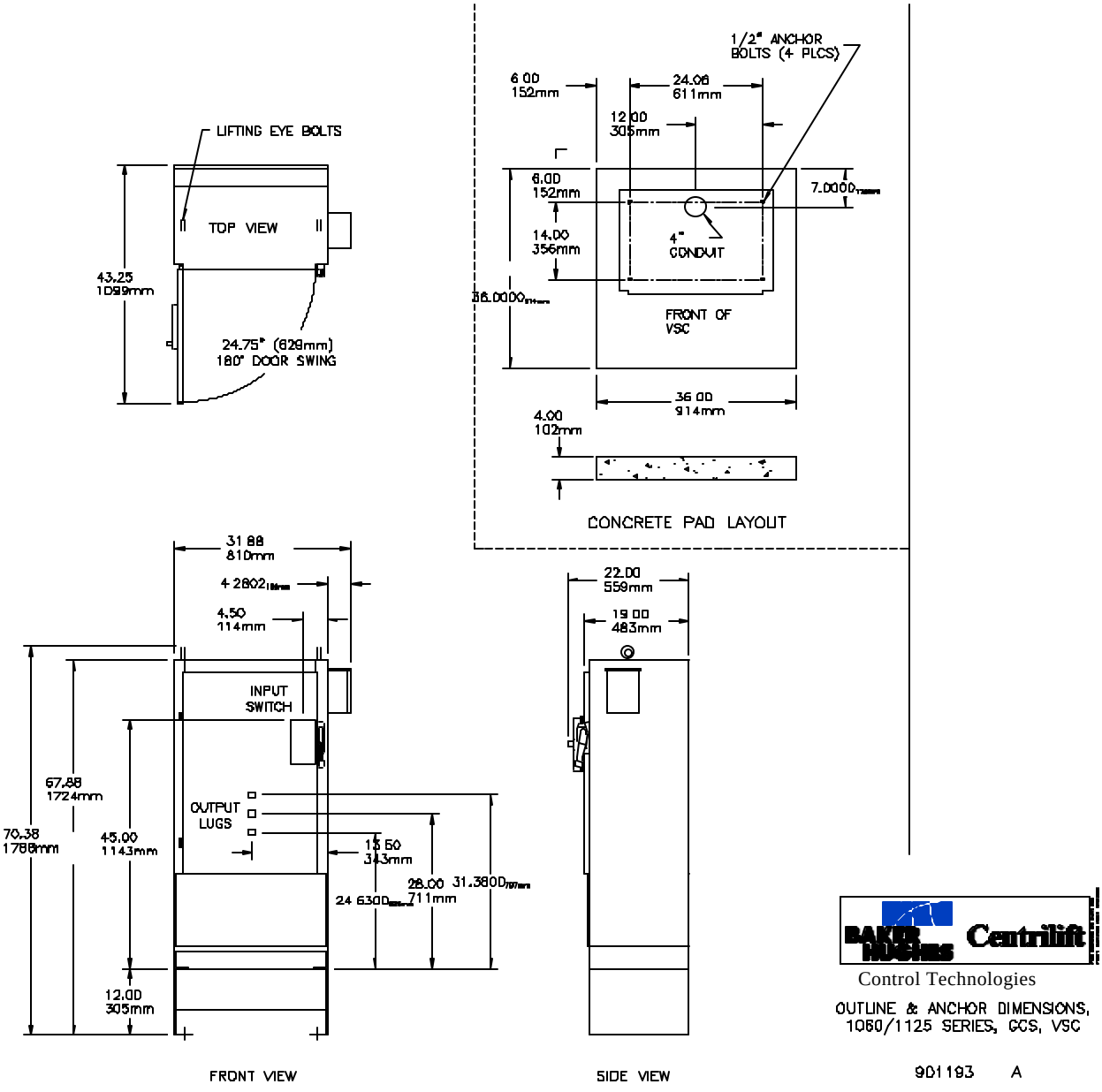
NOTE: OVERLOAD PARAMETER & UNDERLOAD PARAMETER may need to be reset after well has stabilized.

APPENDIX H: WEIGHTS AND DIMENSIONS

Model Number: 1060 GCS Nema 1 Nema 3
Model Number: 1125 GCS (Base Mount)

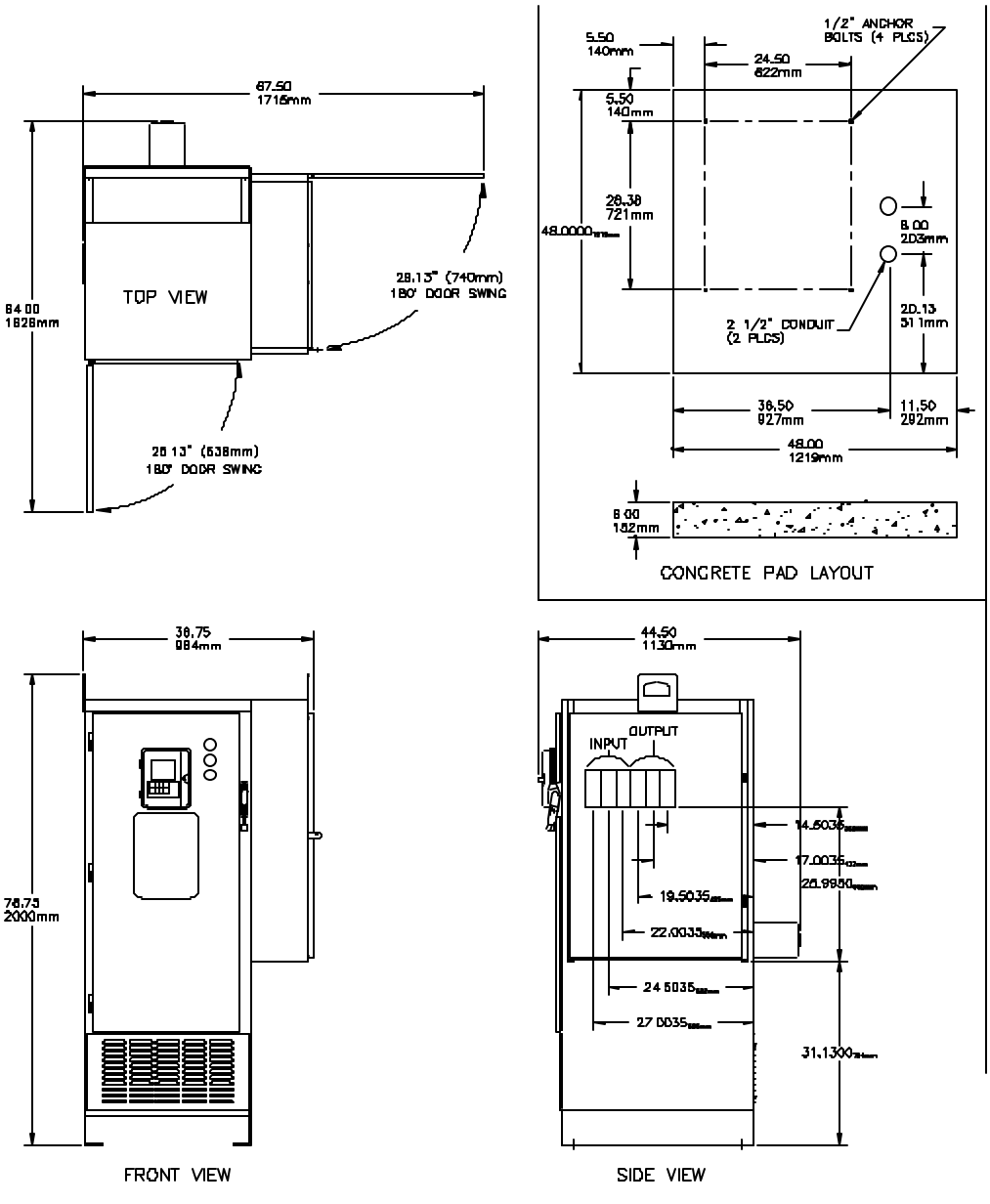
Weight

Overall Height	70.38 in.	70.38 in.
Overall Width	31.88 in.	31.88 in.
Overall Depth	22.00 in.	22.00 in.



Model Number: 2000 GCS

Weight	Nema 1	Nema 3
Overall Height	92.50 in.	78.75 in.
Overall Width	23.63 in.	38.75 in.
Overall Depth	26.63 in.	44.50 in.

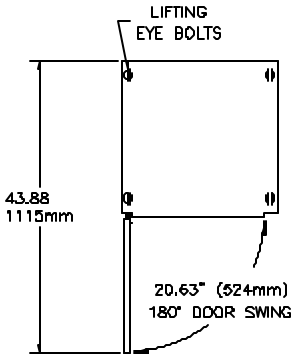


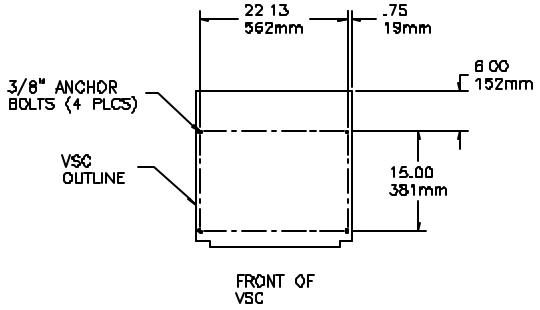
Control Technologies

OUTLINE & ANCHOR DIMENSIONS
2000 SERIES, NEMA 3, GCS, VSC

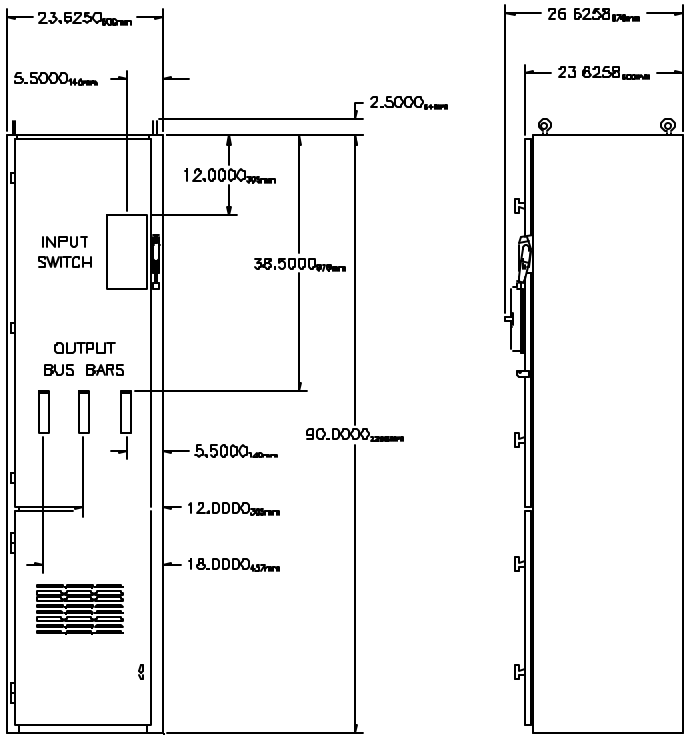
900897 B

2000 NEMA 3, GCS





ANCHOR BOLT PATTERN



FRONT VIEW

SIDE VIEW

2000 NEMA 1, GCS

Centrilift

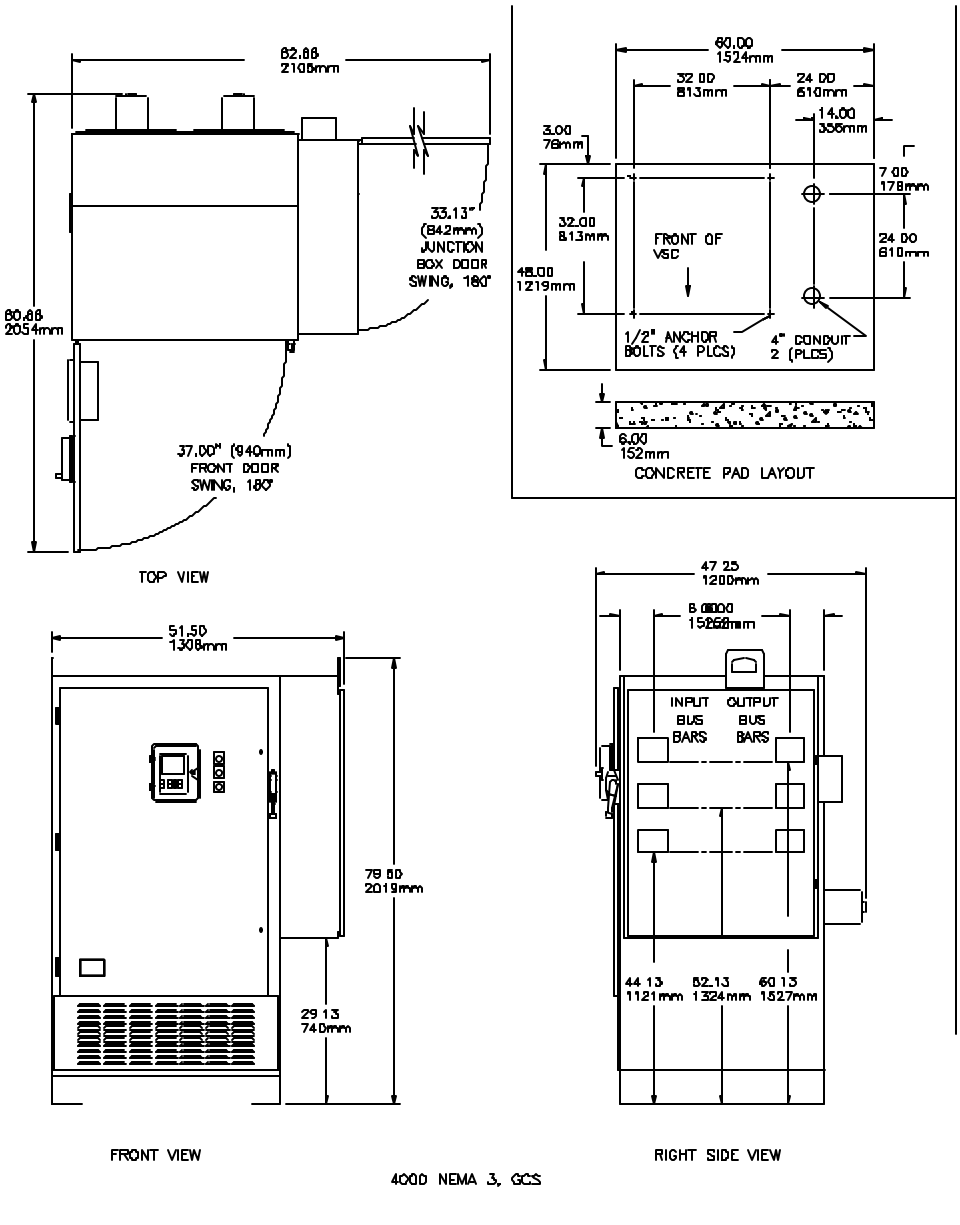
Control Technologies

OUTLINE & ANCHOR DIMENSIONS
2000 SERIES, NEMA 1, GCS, VSC

900998 B

Model Number: 4000 GCS

Weight	Nema 1	Nema 3
Overall Height	92.50 in.	79.50 in.
Overall Width	39.38 in.	51.50 in.
Overall Depth	26.75 in.	47.25 in.



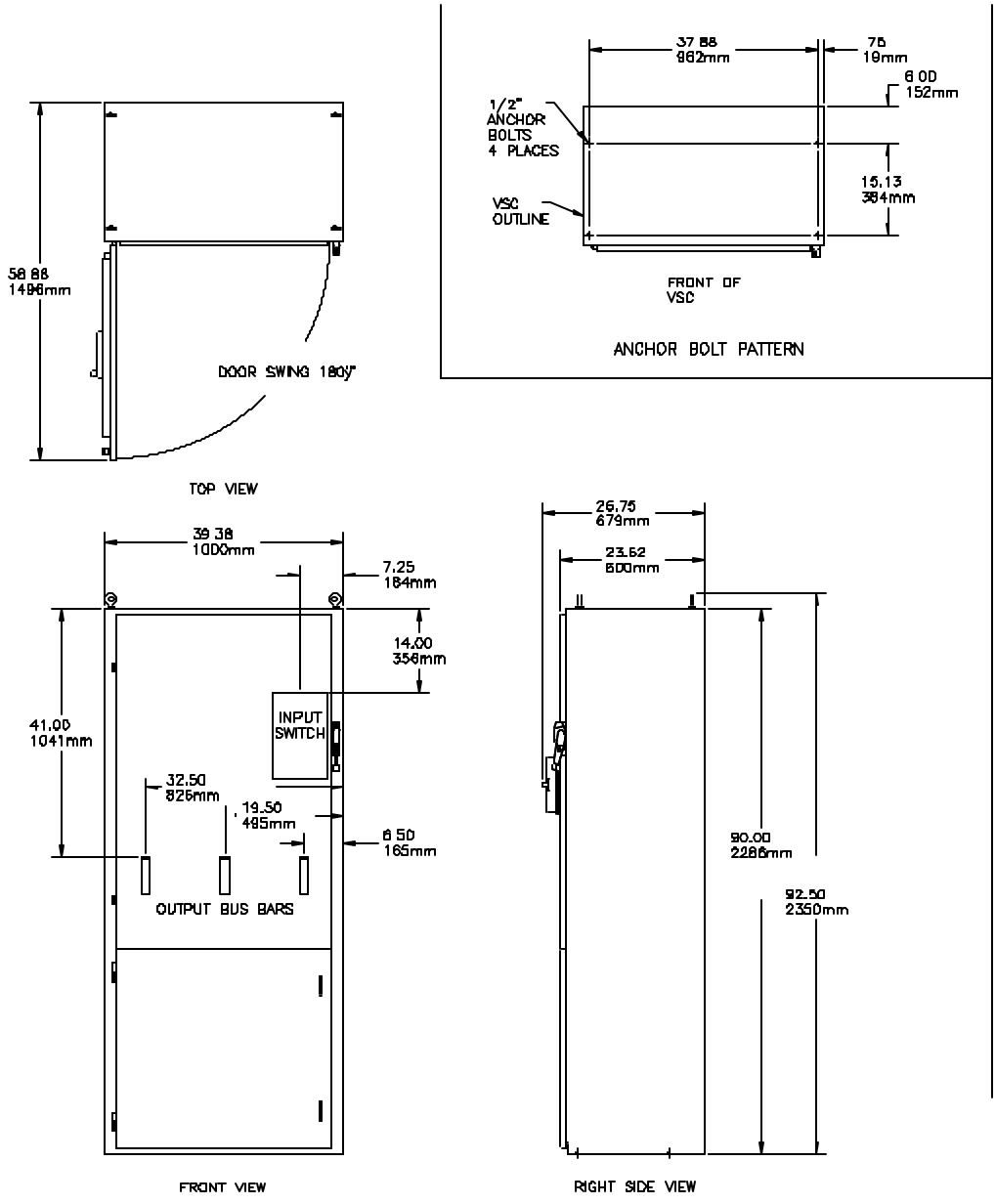
4000 NEMA 3, GCS

Centrilift

Control Technologies

OUTLINE & ANCHOR DIMENSIONS
4000 SERIES, NEMA 3, GCS, VSC

900995 B



4000 NEMA 1, GCS

Centrilift

Control Technologies

OUTLINE & ANCHOR DIMENSIONS
4000 SERIES, NEMA 1, GCS

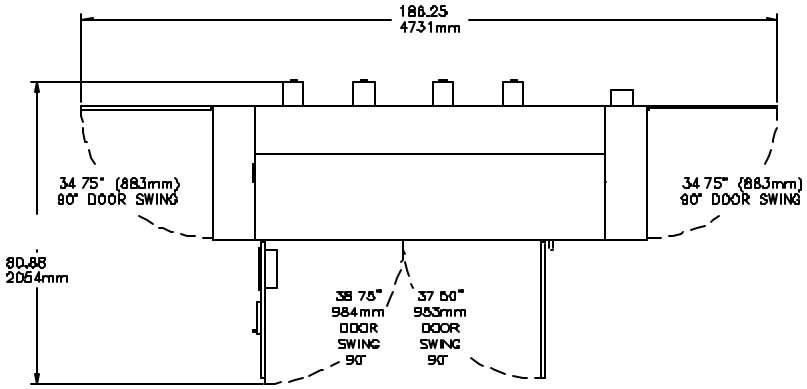
900996 B

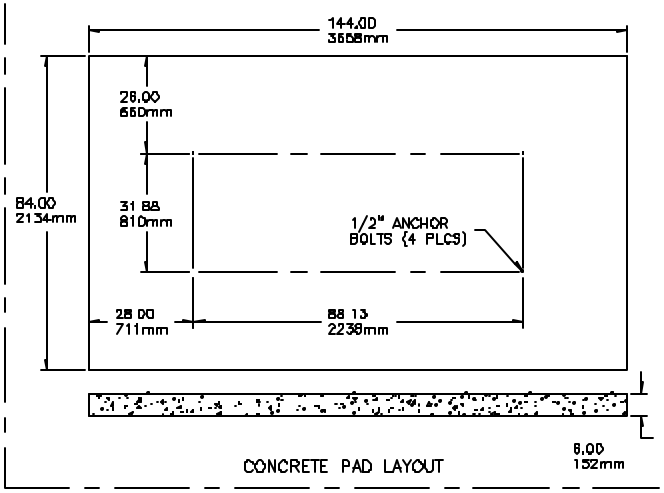
Model Number: 8000 GCS

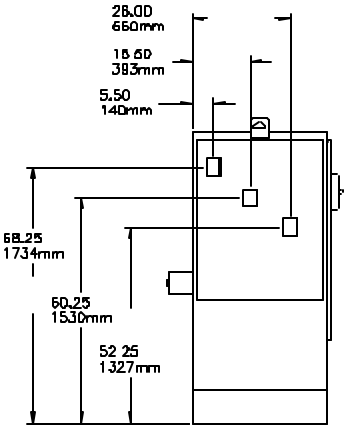
Weight	Nema 1	Nema 3
Overall Height	92.50 in.	80.13 in.
Overall Width	39.38 in. *	120.63 in.
Overall Depth	26.75 in.	47.38 in.

*Two required. Width is double.

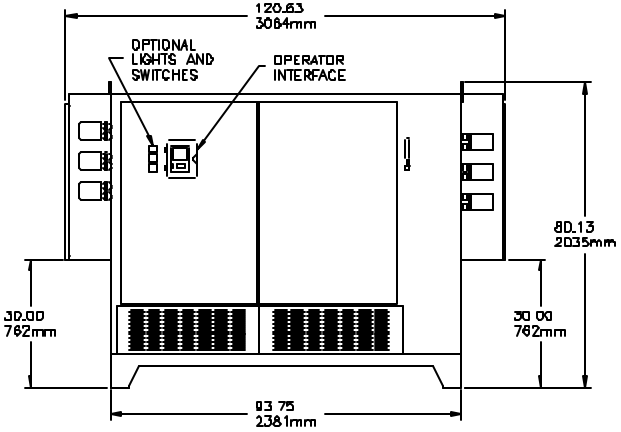
(See next page for drawing)



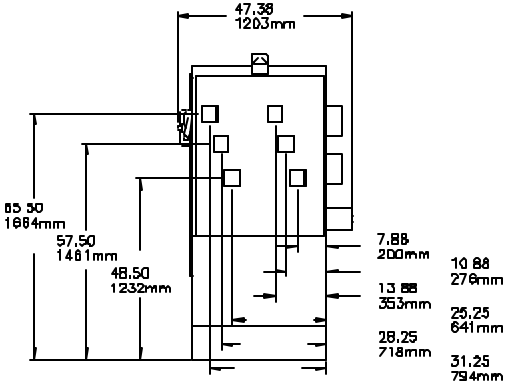




LEFT SIDE VIEW
(OUTPUT LUGS LOCATIONS)



FRONT VIEW



RIGHT SIDE VIEW
(INPUT LUGS LOCATIONS)

Control Technologies

OUTLINE & ANCHOR DIMENSIONS,
8000 SERIES, NEMA 3, GCS, VSC

B011B1 A

APPENDIX I: MODBUS PROTOCOL SUPPORT

1. Introduction

The GCS (Graphic Control System) products support a subset of the functions of Gould Modbus Protocol in RTU (or binary) format as described in Gould Publication PI-MBUS-300, Rev B, dated January 1985.

This technical brief describes the supported functions and the response to each valid request from the host. It is intended to be used in conjunction with the Gould protocol definition and applies to GCS (Graphic Control System) system controller software revision 3.00 or higher. All numeric values shown in the function code request and reply examples are in hexadecimal (base 16) format, even when not denoted with an “H”.

2. Read Output Coil Status (Function Code 01)

Digital output states are read by the host via Function Code 01, "Read Output Status". The first “coil” of this block reflects the state of the motor contactor or RUN state of the controller. If the motor is shut down Coil 0200 H will be set; if it has been requested to start, Coil 0200 H will be clear. All other output status coils will return their status in the same fashion.

For a complete list of the registers, see the tables at the end of this brief.

2.1 Example - Function Code 01

Request:

RTU ADDR	FUNC	START ADDR HIGH	START ADDR LOW	# OF PTS HIGH	# OF PTS LOW	CRC
01H	01H	02H	00H	00H	01H	FCH 72H

Response:

RTU ADDR	FUNC	BYTE COUNT	DATA COIL STATUS	CRC
01H	01H	01H	00H	51H 88H

3. Read Input Status (Function Code 02)

Status inputs are accessed by the host via Function Code 02H, "Read Input Status". These status locations receive their values from devices connected to the I/O channels available or internal processes such as alarms, and can only be read, not altered within the system unit or via Modbus protocol.

For a complete list of the registers, see the tables at the end of this brief.

3.1 Example - Function Code 02

Request:

RTU ADDR	FUNC	START ADDR HIGH	START ADDR LOW	# OF PTS HIGH	# OF PTS LOW	CRC
01H	02H	01H	00H	00H	10H	78H 3AH

Response:

RTU ADDR	FUNC	BYTE COUNT	DATA COIL STATUS	DATA COIL STATUS	CRC
01H	02H	02H	00H	15H	78H 77H

4. Read Output Registers (Function Code 03)

Output registers are read via Function Code 03, "Read Output Registers". Up to 125 registers can be obtained by one request.

For a complete list of the registers, see the tables at the end of this brief.

4.1 Example - Function Code 03

Request:

RTU ADDR	FUNC	START ADDR HIGH	START ADDR LOW	# OF REGS HIGH	# OF REGS LOW	CRC
01H	03H	02H	34H	00H	02H	84H 7DH

Response:

RTU ADDR	FUNC	BYTE COUNT	RETURNING DATA	CRC
01H	03H	04H	00 01 00 00	ABH F3H

5. Read Input Registers (Function Code 04)

Analog inputs are read via Function Code 04, "Read Input Registers". These registers locations receive their values from devices connected to the I/O channels available to the GCS controller and can only be read, not altered directly within the controller or via Modbus protocol. The GCS controller allows up to 125 registers to be obtained by one request. For a complete list of the registers, see the tables at the end of this appendix.

5.1 Example - Function Code 04

Request:

RTU ADDR	FUNC	START ADDR HIGH	START ADDR LOW	# OF REGS HIGH	# OF REGS LOW	CRC
01H	04H	01H	30H	00H	06H	71H FBH

Response:

RTU ADDR	FUNC	BYTE COUNT	RETURNING DATA	CRC
01H	04H	0C	00 00 00 00 00 00 00 00 00 00 00 00	95H B7H

6. Force Single Coil (Function Code 05)

Individual digital outputs (coils) are modified by the Modbus host via Function Code 05, "Force Single Coil". The GCS controller has only three physical digital outputs onboard (relay contacts) but many virtual digital outputs that are used to control various processes in the controller.

6.1 Example - Function Code 05

Request:

RTU ADDR	FUNC	COIL ADDR HIGH	COIL ADDR LOW	DATA ON/OFF	DATA	CRC
01H	05H	02H	00H	FFH	00H	8DH 82H

Response:

RTU ADDR	FUNC	COIL ADDR HIGH	COIL ADDR LOW	DATA ON/OFF	DATA	CRC
01H	05H	02H	00H	FFH	00H	8DH 82H

7. Preset Single Register (Function Code 06)

Individual output registers are modified by the host via Function Code 06, "Preset Single Register".

For a complete list of the registers, see the tables at the end of this brief.

7.1 Example - Function Code 06

Request:

RTU ADDR	FUNC	REG. ADDR HIGH	REG. ADDR LOW	DATA VALUE HIGH	DATA VALUE LOW	CRC
01H	06H	02H	34H	00H	00H	C9H BCH

Response:

RTU ADDR	FUNC	REG. ADDR HIGH	REG. ADDR LOW	DATA VALUE HIGH	DATA VALUE LOW	CRC
01H	06H	02H	34H	00H	00H	C9H BCH

8. Write Multiple Coils (Function Code 15)

Multiple digital outputs are modified by the host in a single message via Function Code 15, "Write Multiple Coils". The GCS controller has only three physical digital outputs (relay contacts) but many virtual digital outputs that are used to control various processes in the controller. For a complete list of the output status points, see the tables at the end of this brief.

8.1 Example - Function Code 15

Request:

RTU ADDR	FUNC	FIRST COIL ADDR HIGH	FIRST COIL ADDR LOW	# OF COILS HIGH	# OF COILS LOW	BYTE COUNT	DATA @ COIL 202H	CRC
01H	0FH	02H	02H	00H	01H	01H	00H	56H B5H

Response:

RTU ADDR	FUNC	FIRST COIL ADDR HIGH	FIRST COIL ADDR LOW	# 0F COILS HIGH	# OF COILS LOW	CRC
01H	0FH	02H	02H	00H	01H	34H 73H

9. Write Multiple Output Registers (Function Code 16)

Multiple output registers are modified by the host via Function Code 16, "Write Multiple Output Registers". For a complete list of the registers, see the tables at the end of this appendix.

9.1 Example - Function Code 16

Request:

RTU ADDR	FUNC	START ADDR HIGH	START ADDR LOW	# OF REGS HIGH	# OF REGS LOW	BYTE COUNT	DATA	CRC
01H	10H	02H	20H	00H	01H	02H	00H 22H	02H E9H

Response:

RTU ADDR	FUNC	START ADDR HIGH	START ADDR LOW	# OF REGS HIGH	# OF REGS LOW	CRC
01H	10H	02H	20H	00H	01H	01H BBH

10. Exception / Error Response

When an error or exception occurs within the GCS controller in response to a host request, it sends a response message to the host consisting of the slave address, the function code, with the high order bit set to one, an exception response code and the CRC error detection word. The following table lists the function code and the error response function code.

10.1 Error Response Function Code

FUNCTION CODE	ERROR RESPONSE FUNCTION CODE
03	83
04	84
05	85
06	86

10.2 Exception Response Code

EXCEPTION RESPONSE CODE	NAME	DESCRIPTION
01	Illegal Function	The requested function is not supported
02	Illegal Data Address	The request contains an out of range data address
03	Illegal Data Value	The request contains out of range data values

11. Status and Register Addresses

The following tables list the available MODBUS style registers including the register description, the hexadecimal register address and the decimal address equivalent formatted in typical SCADA software fashion. The right most column may contain a single letter code denoting that particular register is of meaning only when being accessed on the pertinent GCS controller. The applicable controllers at present are the Electrospeed GCS, Vortex GCS and Tracker GCS.

INPUT STATUS
(READ INPUT STATUS = FUNCTION CODE 02)

(V =Vortex, E =Electrospeed, T =Tracker)

DIGITAL_IN1_SD_ALARM	Digital Input 1 Shutdown Alarm	0x0100	10257	
DIGITAL_IN2_SD_ALARM	Digital Input 2 Shutdown Alarm	0x0101	10258	
IUNBAL_SD_ALARM	Current Unbalance Shutdown Alarm	0x0102	10259	
VUNBAL_SD_ALARM	Voltage Unbalance Shutdown Alarm	0x0103	10260	
OVERVOLT_SD_ALARM	Over Voltage Shutdown Alarm	0x0104	10261	
UNDERVOLT_SD_ALARM	Under Voltage Shutdown Alarm	0x0105	10262	
UNDERLOAD_SD_ALARM	Undercurrent Shutdown Alarm	0x0106	10263	
OVERLOAD_SD_ALARM	Over current Shutdown Alarm	0x0107	10264	
CONTACTOR	Status of motor contactor	0x0108	10265	
RED	Status of relay contacts for Red panel light	0x0109	10266	
AUTO	Optional HOA mode switch in “AUTO”	0x010A	10267	
HAND	Optional HOA mode switch in “HAND”	0x010B	10268	
LOCKOUT	Status of Auto restarts Lockout / permit	0x010C	10269	
START	Optional Start switch input status	0x010D	10270	
ROTATION_ALARM	Incoming phase rotation change alarm	0x010E	10271	
ANALOG1_HI_THLD_SD_ALARM	High Threshold Shutdown Alarm	0x010F	10272	
ANALOG1_LO_THLD_SD_ALARM	Low Threshold Shutdown Alarm	0x0110	10273	
ANALOG2_HI_THLD_SD_ALARM	High Threshold Shutdown Alarm	0x0111	10274	
ANALOG2_LO_THLD_SD_ALARM	Low Threshold Shutdown Alarm	0x0112	10275	
NULL_POINT	Unused /Reserved	0x0113	10276	
DIGITAL_IN1_SDSTATE_TRUE	Digital In 1 in Alarm, in Shutdown Delay	0x0114	10277	
DIGITAL_IN2_SDSTATE_TRUE	Digital In 2 in Alarm, in Shutdown Delay	0x0115	10278	
OVERLOAD_HI_THLD_XCEED	Overload in Alarm, in Shutdown Delay	0x0116	10279	
UNDERLOAD_LO_THLD_XCEED	Underload in Alarm, in Shutdown Delay	0x0117	10280	
ANALOG1_HI_THLD_XCEED	Analog1 Hi in Alarm, in Shutdown Delay	0x0118	10281	
DIGITAL_IN3_SD_ALARM	Digital Input 3 Shutdown Alarm	0x0119	10282	E
OVERVOLT_HI_THLD_XCEED	Over Voltage in Alarm, in Shutdown Delay	0x011A	10283	
UNDERLOAD_LO_THLD_XCEED	Under Current Alarm, in Shutdown Delay	0x011B	10284	
ROTATION_SDSTATE_TRUE	Incoming Phase Rotation has Changed	0x011C	10285	
ANALOG1_LO_THLD_XCEED	Analog1 Lo in Alarm, in Shutdown Delay	0x011D	10286	
ANALOG2_HI_THLD_XCEED	Analog 2 Hi in Alarm, in Shutdown Delay	0x011E	10287	
ANALOG2_LO_THLD_XCEED	Analog 2 Lo in Alarm, in Shutdown Delay	0x011F	10288	
PCM_CONSTANT_TORQUE	Constant Torque Mode	0x0120	10289	E
PCM_ILIMIT	Current Limit Active	0x0121	10290	E

3

OUTPUT STATUS BLOCK 1

READ STATUS (Read Output Coil Status = FUNCTION CODE 01)
WRITE OUTPUT (Force Single Coil = FUNCTION CODE 05)
WRITE OUTPUTS (Force Multiple Coils = FUNCTION CODE 15)

(V =Vortex, E =Electrospeed, T =Tracker)

CENTRAL_SHUTDOWN_REQUEST	SCADA / Remote Control Shutdown	0x0200	00513	
NULL_POINT	reserved	0x0201	00514	
OVERLOAD_LOCK_ENBL	Disallow Restart if Overload Shutdown	0x0202	00515	
OVERLOAD_ALARM_ENBL	Alarm or Ignore Overload condition	0x0203	00516	V
UNDERLOAD_LOCK_ENBL	Disallow Restart if Underload Shutdown	0x0204	00517	
UNDERLOAD_ALARM_ENBL	Alarm or Ignore Underload condition	0x0205	00518	
UNDERVOLT_LOCK_ENBL	Disallow Restart if UnderVolt Shutdown	0x0206	00519	
UNDERVOLT_ALARM_ENBL	Alarm or Ignore UnderVolt condition	0x0207	00520	
OVERVOLT_LOCK_ENBL	Disallow Restart if OverVolt Shutdown	0x0208	00521	
OVERVOLT_ALARM_ENBL	Alarm or Ignore OverVolt condition	0x0209	00522	
VUNBAL_LOCK_ENBL	Disallow Restart if OverVolt Shutdown	0x020A	00523	
VUNBAL_ALARM_ENBL	Alarm or Ignore OverVolt condition	0x020B	00524	
IUNBAL_LOCK_ENBL	No Restart \ Amps Unbalance Shutdown	0x020C	00525	
IUNBAL_ALARM_ENBL	Alarm \ Ignore Amps Unbalance	0x020D	00526	
DIGITAL_IN2_LOCK_ENBL	Disallow Restart if Digital In2 Shutdown	0x020E	00527	
DIGITAL_IN2_ALARM_ENBL	Alarm or Ignore Digital In2 condition	0x020F	00528	
DIGITAL_IN1_LOCK_ENBL	Disallow Restart if Digital In1 Shutdown	0x0210	00529	
DIGITAL_IN1_ALARM_ENBL	Alarm or Ignore Digital In1 condition	0x0211	00530	
ANALOG1_HI_THLD_LOCK_ENBL	Disallow Restart if Analog In1 Shutdown	0x0212	00531	
ANALOG1_HI_THLD_ALARM_ENBL	Alarm or Ignore Analog In1 condition	0x0213	00532	
ROTATION_LOCK_ENBL	Disallow Restart if Rotation Shutdown	0x0214	00533	
ROTATION_ALARM_ENBL	Alarm or Ignore Rotation condition	0x0215	00534	
ANALOG1_LO_THLD_LOCK_ENBL	Disallow Restart if Analog In1 Shutdown	0x0216	00535	
ANALOG1_LO_THLD_ALARM_ENBL	Alarm or Ignore Analog In1 condition	0x0217	00536	
WAIT_FOR_RESTART_TIMER	No operator starts until timer expires	0x0218	00537	
SCADA_START	SCADA Start command	0x0219	00538	
SCADA_STOP	SCADA Stop command	0x021A	00539	
ANALOG2_HI_THLD_LOCK_ENBL	Disallow Restart if Analog 2 High shutdown	0x021B	00540	
ANALOG2_HI_THLD_ALARM_ENBL	Alarm or Ignore Analog In 2 High condition	0x021C	00541	
ANALOG2_LO_THLD_LOCK_ENBL	Disallow Restart if Analog 2 Low shutdown	0x021D	00542	
ANALOG2_LO_THLD_ALARM_ENBL	Alarm or Ignore Analog In 2 Low condition	0x021E	00543	
KEYPAD_AUTO	Indicate Auto restart mode selected on keypad	0x021F	00544	
ANALOG1_HI_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0220	00545	
ANALOG1_LO_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0221	00546	
ANALOG2_HI_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0223	00547	
ANALOG2_LO_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0224	00548	
DIGITAL_IN1_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0225	00549	
DIGITAL_IN2_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0226	00550	
IUNBAL_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0227	00551	
OVERLOAD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0228	00552	
OVERVOLT_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0229	00553	
UNDERLOAD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x022A	00554	
UNDERVOLT_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x022B	00555	
VUNBAL_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x022C	00556	
INVERT_FREQ_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x022D	00557	E
PWR_FACTOR_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x022E	00558	

OUTPUT STATUS BLOCK 1

READ STATUS (Read Output Coil Status = FUNCTION CODE 01)
WRITE OUTPUT (Force Single Coil = FUNCTION CODE 05)
WRITE OUTPUTS (Force Multiple Coils = FUNCTION CODE 15)

(V =Vortex, E =Electrospeed, T =Tracker)

HSINK1_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x022F	00559	E
HSINK2_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0230	00560	E
HSINK3_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0231	00561	E
HSINK4_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0232	00562	E
INDUCTOR_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0233	00563	E
AMBIENT_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0234	00564	E
AUX_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0235	00565	E
OUT_FREQ_THLD_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0236	00566	E
ROTATION_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0237	00567	
PCM_FAULT_ARP_ENBL	Enable/Disable auxiliary restart parameters	0x0238	00568	E

OUTPUT STATUS BLOCK 2

READ STATUS (Read Output Coil Status = FUNCTION CODE 01)
COIL OUTPUTS (Force Single Coil = FUNCTION CODE 05)
COIL OUTPUTS (Force Multiple Coils = FUNCTION CODE 15)

(V =Vortex, E =Electrospeed, T =Tracker)

EXTERNAL_HOA	External Mode Switch enable / disable	0x0300	00769	
SINGLE_PTCONFIGURATION	One / two voltage monitoring xformers	0x0301	00770	V
DAY_LIGHT_SAVINGS	Enable/disable Daylight Savings Time	0x0302	00771	
PWR_FACTOR_THLD_ALRM_ENBL	Alarm or Ignore Low Power Factor condition	0x0303	00772	
PWR_FACTOR_THLD_LOCK_ENBL	Disallow Restart if Power Factor shutdown	0x0304	00773	
RESET_HISTORY_DATABASE	Erases the historical database	0x0305	00774	
VCA0_XING_ALARM	Indicates loss of input voltage C-A	0x0306	00775	
PCM_INVERTER_IN_TEST_MODE	Inverter runs regardless of Bus Voltage	0x0307	00776	E

INPUT REGISTERS (READ ONLY)

(READ INPUT REGISTERS = FUNCTION CODE 04)

(V =Vortex, E =Electrospeed, T =Tracker)

IA_MOTOR	Scaled Output Current Phase A	0x0101	30258	
IB_MOTOR	Scaled Output Current Phase B	0x0102	30259	
IC_MOTOR	Scaled Output Current Phase C	0x0103	30260	
VAB_MOTOR	Scaled In/Output Voltage Phase A to B	0x0104	30261	
VBC_MOTOR	Scaled In/Output Voltage Phase B to C	0x0105	30262	
VCA_MOTOR	Scaled In/Output Voltage Phase C to A	0x0106	30263	
POWER_FACTOR	Efficiency of Power usage 0-100%	0x0107	30264	
TIME_TIL_RESTART_MINUTES	Time until motor is auto restarted	0x0108	30265	
ANALOG1	Scaled value of Analog input #1	0x0109	30266	
RESET_RUN_TIME_HOURS	User Resettable motor runtime counter	0x010A	30267	
TOTAL_RUN_TIME_HOURS	Non-resettable motor runtime counter	0x010B	30268	
STARTS_ACCUMULATOR	Total motor starts	0x010C	30269	
VUNBAL	Present value of Input Voltage unbalance	0x010D	30270	
IUNBAL	Present value of output Current unbalance	0x010E	30271	
RUN_TIME_HOURS	Motor runtime since last start counter	0x010F	30272	
NUMBER_OF_STARTS	Number of “Auto” restarts attempted	0x0110	30273	
ANALOG2	Scaled value of Analog input #2	0x0111	30274	
TIME_TIL_RESTART_SECONDS	Time until motor is auto restarted	0x0112	30275	

INPUT REGISTERS (READ ONLY)

(READ INPUT REGISTERS = FUNCTION CODE 04)

(V =Vortex, E =Electrospeed, T =Tracker)

RUN_TIME_MINUTES	Run time since last start	0x0113	30276	
RUN_TIME_SECONDS	Run time since last start	0x0114	30277	
RUN_TIME_DAYS	Run time since last start	0x0115	30278	
TOTAL_RUN_TIME_DAYS	Accumulated Run time since commissioning	0x0116	30279	
TOTAL_RUN_TIME_MINUTES	Accumulated Run time since commissioning	0x0117	30280	
TOTAL_RUN_TIME_SECONDS	Accumulated Run time since commissioning	0x0118	30281	
RESET_RUN_TIME_DAYS	Run time since last user reset	0x0119	30282	
RESET_RUN_TIME_MINUTES	Run time since last user reset	0x011A	30283	
RESET_RUN_TIME_SECONDS	Run time since last user reset	0x011B	30284	
IN_SERVICE_YEAR	Commissioning date	0x011C	30285	
IN_SERVICE_MONTH	Commissioning date	0x011D	30286	
IN_SERVICE_DAY	Commissioning date	0x011E	30287	
TOTAL_DOWN_TIME_DAYS	Accumulated Down time since first shutdown	0x011F	30288	
TOTAL_DOWN_TIME_HOURS	Accumulated Down time since first shutdown	0x0120	30289	
TOTAL_DOWN_TIME_MINUTES	Accumulated Down time since first shutdown	0x0121	30290	
DOWN_TIME_DAYS	Down time since last shutdown	0x0122	30291	
DOWN_TIME_HOURS	Down time since last shutdown	0x0123	30292	
DOWN_TIME_MINUTES	Down time since last shutdown	0x0124	30293	
TOTAL_DOWN_TIME_SECONDS	Accumulated Down time since first shutdown	0x0125	30294	
DOWN_TIME_SECONDS	Down time since last shutdown	0x0126	30295	
DRIVE_MODEL_NO	Electrospeed model number	0x0127	30296	E
PCM_CT_RATIO	Power Conversion Module CT Ratio	0x0128	30297	E
OUTPUT_FREQUENCY	Present operating output frequency	0x0129	30298	E
IA_SCALED	Input current phase A	0x012A	30299	
IB_SCALED	Input current phase B	0x012B	30300	
IC_SCALED	Input current phase C	0x012C	30301	
VAB_SCALED	Input Voltage phase AB	0x012D	30302	
VBC_SCALED	Input Voltage phase BC	0x012E	30303	
VCA_SCALED	Input Voltage phase CA	0x012F	30304	
TRACK_CHANNEL1	Present value of Tracker channel 1	0x0130	30305	T
TRACK_CHANNEL2	Present value of Tracker channel 2	0x0131	30306	T
TRACK_CHANNEL3	Present value of Tracker channel 3	0x0132	30307	T
TRACK_CHANNEL4	Present value of Tracker channel 4	0x0133	30308	T
TRACK_CHANNEL5	Present value of Tracker channel 5	0x0134	30309	T
TRACK_CHANNEL6	Present value of Tracker channel 6	0x0135	30310	T
TRACK_CHANNEL7	Present value of Tracker channel 7			T
TRACK_CHANNEL8	Present value of Tracker channel 8			T

OUTPUT REGISTERS BLOCK 1

(READ OUTPUT REGISTERS = FUNCTION CODE 03)
(PRESET SINGLE REGISTER = FUNCTION CODE 06)
(PRESET MULTIPLE REGISTERS = FUNCTION CODE 16)

(V =Vortex, E =Electrospeed, T =Tracker)

RESTART_DELAY_MINUTES	User set restart time delay	0x0201	40514	
CTRATIO	Current transformer ratio XXX:100	0x0202	40515	V
OVERLOAD_HI_THLD	Overload shutdown threshold	0x0203	40516	V
UNDERLOAD_LO_THLD	Underload shutdown threshold	0x0204	40517	

OUTPUT REGISTERS BLOCK 1

(READ OUTPUT REGISTERS = FUNCTION CODE 03)
(PRESET SINGLE REGISTER = FUNCTION CODE 06)
(PRESET MULTIPLE REGISTERS = FUNCTION CODE 16)

(V =Vortex, E =Electrospeed, T =Tracker)

OVERVOLT_HI_THLD	Overvoltage shutdown threshold	0x0205	40518	
UNDERVOLT_LO_THLD	Undervoltage shutdown threshold	0x0206	40519	
ROTATION_SDSTATE	Live status of Rotation alarm	0x0207	40520	
USER_PASSWORD	Security password, level 1	0x0208	40521	
ANALOG1_SPAN	Analog 1 Span multiplier	0x0209	40522	
ANALOG1_LO_THLD	Analog 1 Low Alarm Threshold	0x020A	40523	
VUNBAL_HI_THLD	Voltage Unbalance Alarm Threshold	0x020B	40524	
IUNBAL_HI_THLD	Current Unbalance Alarm Threshold	0x020C	40525	
NUMBER_OF_ALLOWED_START	Allowed # of automatic restarts before lockout	0x020D	40526	
RESET_COUNTER_DELAY_MIN	Time motor must run to reset # of auto-restarts	0x020E	40527	
OVERLOAD_LEGACY	Reserved for VMC-100 compatibility	0x020F	40528	
UNDERLOAD_LEGACY	Reserved for VMC-100 compatibility	0x0210	40529	
UNDERVOLT_LEGACY	Reserved for VMC-100 compatibility	0x0211	40530	
OVERVOLT_LEGACY	Reserved for VMC-100 compatibility	0x0212	40531	
VUNBAL_LEGACY	Reserved for VMC-100 compatibility	0x0213	40532	
IUNBAL_LEGACY	Reserved for VMC-100 compatibility	0x0214	40533	
DIGITAL_IN2_LEGACY	Reserved for VMC-100 compatibility	0x0215	40534	
DIGITAL_IN1_LEGACY	Reserved for VMC-100 compatibility	0x0216	40535	
ANALOG1_HI_LEGACY	Reserved for VMC-100 compatibility	0x0217	40536	
OVERLOAD_SD_DELAY	Overload Alarm shutdown delay	0x0218	40537	
UNDERLOAD_SD_DELAY	Underload Alarm shutdown delay	0x0219	40538	
UNDERVOLT_SD_DELAY	Undervoltage Alarm shutdown delay	0x021A	40539	
OVERVOLT_SD_DELAY	Overvoltage Alarm shutdown delay	0x021B	40540	
VUNBAL_SD_DELAY	Voltage Unbalance Alarm shutdown delay	0x021C	40541	
IUNBAL_SD_DELAY	Current Unbalance Alarm shutdown delay	0x021D	40542	
DIGITAL_IN2_SD_DELAY	Digital Input 2 Alarm shutdown delay	0x021E	40543	
DIGITAL_IN1_SD_DELAY	Digital Input 1 Alarm shutdown delay	0x021F	40544	
ANALOG1_HI_THLD_SD_DELAY	Analog In 1 High Threshold Alarm shutdown delay	0x0220	40545	
OVERLOAD_BP_DELAY	Overload Alarm Start Bypass delay	0x0221	40546	
UNDERLOAD_BP_DELAY	Underload Alarm Start Bypass delay	0x0222	40547	
UNDERVOLT_BP_DELAY	Undervoltage Alarm Start Bypass delay	0x0223	40548	
OVERVOLT_BP_DELAY	Overvoltage Alarm Start Bypass delay	0x0224	40549	
VUNBAL_BP_DELAY	Voltage Unbalance Alarm Start Bypass delay	0x0225	40550	
IUNBAL_BP_DELAY	Current Unbalance Alarm Start Bypass delay	0x0226	40551	
DIGITAL_IN2_BP_DELAY	Digital In 2 Alarm Start Bypass delay	0x0227	40552	
DIGITAL_IN1_BP_DELAY	Digital In 1 Alarm Start Bypass delay	0x0228	40553	
ANALOG1_HI_THLD_BP_DELAY	Analog In 1 Hi Threshold Alarm Start Bypass delay	0x0229	40554	
VOLTAGE_DEMO_MODE	Voltage Demonstration Mode (Single phase)	0x022A	40555	V
PROGRESS_RESTART_INC	Progressive Restart Time Delay Increment	0x022B	40556	
VCA_PERIOD	Period of Voltage CA wave form in “counts”	0x022C	40557	
WAIT_FOR_RESTART_TIMER	Disable all starts until Restart Time delay expires	0x022D	40558	
TEMPERATURE_CALIBRATION		0x022E	40559	
LOCKOUT_PASSWORD_ENBL	Password required to clear lockout condition	0x022F	40560	
CENTRAL_SHUTDOWN_REQUEST		0x0230	40561	
NULL_POINT		0x0231	40562	
NULL_POINT		0x0232	40563	

OUTPUT REGISTERS BLOCK 1

(READ OUTPUT REGISTERS = FUNCTION CODE 03)
(PRESET SINGLE REGISTER = FUNCTION CODE 06)
(PRESET MULTIPLE REGISTERS = FUNCTION CODE 16)

(V =Vortex, E =Electrospeed, T =Tracker)

LEVEL2_PASSWORD	Level 2 security password	0x0233	40564	
RTU_ADDRESS	SCADA system terminal address	0x0234	40565	
TRANSMIT_DELAY	Time delay between RTS/PTT and transmit	0x0235	40566	
CT_PHASE	Current transformer phasing	0x0236	40567	
PROGRAM_REVISION_NUMBER	System Unit's Firmware Revision Number	0x0237	40568	
USER_PASSWORD_TIMEOUT	Inactivity delay before blanking user password	0x0238	40569	
UPDATE_FLASH_NOW	Force write of parameters to non-volatile Memory	0x0239	40570	
PWR_FACTOR_THLD	Power factor alarm shutdown threshold	0x023A	40571	
PWR_FACTOR_THLD_SD_DELAY	Power factor alarm shutdown time delay	0x023B	40572	
PWR_FACTOR_THLD_BP_DELAY	Power factor alarm start bypass time delay	0x023C	40573	
AMBIENT_TEMP	Present reading of ambient temperature sensor	0x023D	40574	E
ANALOG2_SPAN	Analog 2 span multiplier	0x023E	40575	
ANALOG1_HI_THLD	Analog 1 High Alarm Threshold	0x023F	40576	
COMMUNICATIONS_PROTOCOL	Communications Language 1=Modbus	0x0240	40577	
NULL_POINT		0x0241	40578	
KILO_WATTS	Instantaneous power consumption	0x0242	40579	
GIGA_WATT_HOURS	Accumulated power consumption in GigaWatts	0x0243	40580	
MEGA_WATT_HOURS	Accumulated power consumption in MegaWatts	0x0244	40581	
KILO_WATT_HOURS	Accumulated power consumption in KiloWatts	0x0245	40582	
NULL_POINT		0x0246	40583	
BAUD_RATE	RS-232 ports comm. rate in bits per second	0x0247	40584	
NULL_POINT		0x0248	40585	
TIMERS_IN_MINUTES	Reserved for VMC-100 compatibility	0x0249	40586	
CITIBUS_NODE_STATUS	CitiBus communications status	0x024A	40587	
RESET_ALL_SETPOINTS	Force all setpoints to factory default values	0x024B	40588	
IA_SPAN	Phase A current span multiplier	0x024C	40589	
IB_SPAN	Phase B current span multiplier	0x024D	40590	
IC_SPAN	Phase C current span multiplier	0x024E	40591	
VAB_SPAN	Phase AB voltage span multiplier	0x024F	40592	
VBC_SPAN	Phase BC voltage span multiplier	0x0250	40593	
VCA_SPAN	Phase CA voltage span multiplier	0x0251	40594	
WATCHDOG_RESETS	Microprocessor Reset Status Register	0x0252	40595	
SET_REAL_TIME_CLOCK	Force real time clock to new "SET" values	0x0253	40596	
SET_DAY_OF_WEEK	New setting for real time day of week: 1=Sunday	0x0254	40597	
SET_SECONDS	New setting for real time seconds: 0-59	0x0255	40598	
SET_MINUTES	New setting for real time minutes: 0-59	0x0256	40599	
SET_HOURS	New setting for real time hours: 0-24	0x0257	40600	
SET_DATE	New setting for real time date: 1-31	0x0258	40601	
SET_MONTH	New setting for real time month: 1-12	0x0259	40602	
SET_YEAR	New setting for real time year: 1900 -2035	0x025A	40603	
ANALOG1_HI_THLD_AUTO_RST	Analog 1 Hi-Threshold ARP restarts allowed	0x025B	40604	
ANALOG1_LO_THLD_AUTO_RST	Analog 1 Lo-Threshold ARP restarts allowed	0x025C	40605	
ANALOG2_HI_THLD_AUTO_RST	Analog 2 Hi-Threshold ARP restarts allowed	0x025D	40606	
ANALOG2_LO_THLD_AUTO_RST	Analog 2 Lo-Threshold ARP restarts allowed	0x025E	40607	
DIGITAL_IN1_AUTO_RESTART	Digital Input 1 ARP restarts allowed	0x025F	40608	
DIGITAL_IN2_AUTO_RESTART	Digital Input 2 ARP restart allowed	0x0260	40609	

OUTPUT REGISTERS BLOCK 1

(READ OUTPUT REGISTERS = FUNCTION CODE 03)
(PRESET SINGLE REGISTER = FUNCTION CODE 06)
(PRESET MULTIPLE REGISTERS = FUNCTION CODE 16)

(V =Vortex, E =Electrospeed, T =Tracker)

IUNBAL_AUTO_RESTARTS	Current Unbalance ARP restarts allowed	0x0261	40610	
OVERLOAD_AUTO_RESTARTS	Overload ARP restarts allowed	0x0262	40611	
OVERVOLT_AUTO_RESTARTS	Overvolt ARP restarts allowed	0x0263	40612	
UNDERLOAD_AUTO_RESTARTS	Underload ARP restarts allowed	0x0264	40613	
UNDERVOLT_AUTO_RESTARTS	Undervoltage ARP restarts allowed	0x0265	40614	
VUNBAL_AUTO_RESTARTS	Voltage Unbalance ARP restarts allowed	0x0266	40615	
INVERT_FREQ_AUTO_RESTART	Inverter frequency ARP restarts allowed	0x0267	40616	E
PWR_FACTOR_THLD_AUTO_RST	Power factor ARP restarts allowed	0x0268	40617	
HSINK1_THLD_AUTO_RESTART	Heat Sink 1 ARP restarts allowed	0x0269	40618	E
HSINK2_THLD_AUTO_RESTART	Heat Sink 2 ARP restarts allowed	0x026A	40619	E
HSINK3_THLD_AUTO_RESTART	Heat Sink 3 ARP restarts allowed	0x026B	40620	E
HSINK4_THLD_AUTO_RESTART	Heat Sink 4 ARP restarts allowed	0x026C	40621	E
INDUCTOR_THLD_AUTO_RST	Inductor temp sensor ARP restarts allowed	0x026D	40622	E
AMBIENT_THLD_AUTO_RST	Ambient temp sensor ARP restarts allowed	0x026E	40623	E
AUX_THLD_AUTO_RESTARTS	Auxiliary temp sensor ARP restarts allowed	0x026F	40624	E
OUT_FREQ_THLD_AUTO_RST	Output frequency ARP restarts allowed	0x0270	40625	E
ROTATION_AUTO_RESTARTS	Rotation ARP restarts allowed	0x0271	40626	
PCM_FAULT_AUTO_RESTARTS	PCM Fault ARP restarts allowed	0x0272	40627	E
ANALOG1_HI_THLD_RST_DLY	Analog 1 Hi threshold ARP restart delay	0x0273	40628	
ANALOG1_LO_THLD_RST_DLY	Analog 1 Lo threshold ARP restart delay	0x0274	40629	
ANALOG2_HI_THLD_RST_DLY	Analog 2 Hi threshold ARP restart delay	0x0275	40630	
ANALOG2_LO_THLD_RST_DLY	Analog 2 Lo threshold ARP restart delay	0x0276	40631	
DIGITAL_IN1_RESTART_DLY	Digital input 1 ARP restart delay	0x0277	40632	
DIGITAL_IN2_RESTART_DLY	Digital input 2 ARP restart delay	0x0278	40633	
IUNBAL_RESTART_DELAY	Current Unbalance ARP restart delay	0x0279	40634	
OVERLOAD_RESTART_DELAY	Overload ARP restart delay	0x027A	40635	
OVERVOLT_RESTART_DELAY	Overvoltage ARP restart delay	0x027B	40636	
UNDERLOAD_RESTART_DELAY	Underload ARP restart delay	0x027C	40637	
UNDERVOLT_RESTART_DELAY	Undervoltage ARP restart delay	0x027D	40638	
VUNBAL_RESTART_DELAY	Voltage Unbalance ARP restart delay	0x027E	40639	
INVERT_FREQ_RESTART_DLY	Inverter Frequency ARP restart delay	0x027F	40640	E
PWR_FACTOR_THLD_RST_DLY	Power Factor ARP restart delay	0x0280	40641	
HSINK1_THLD_RESTART_DLY	Heat sink 1 ARP restart delay	0x0281	40642	E
HSINK2_THLD_RESTART_DLY	Heat sink 2 ARP restart delay	0x0282	40643	E
HSINK3_THLD_RESTART_DLY	Heat sink 3 ARP restart delay	0x0283	40644	E
HSINK4_THLD_RESTART_DLY	Heat sink 4 ARP restart delay	0x0284	40645	E
INDUCTOR_THLD_RST_DELAY	Inductor temp sensor ARP restart delay	0x0285	40646	E
AMBIENT_THLD_RST_DELAY	Ambient temp sensor ARP restart delay	0x0286	40647	E
AUX_THLD_RESTART_DELAY	Auxiliary temp sensor ARP restart delay	0x0287	40648	E
OUT_FREQ_THLD_RST_DELAY	Output frequency ARP restart delay	0x0288	40649	E
ROTATION_RESTART_DELAY	Rotation ARP restart delay	0x0289	40650	E
PCM_FAULT_RESTART_DELAY	PCM Fault ARP restart delay	0x028A	40651	E
RUN_FREQUENCY	Variable speed drive frequency setpoint	0x028B	40652	E
VAB_COUNTS_AT_ZERO	Volt phase AB factory calibration setpoint	0x028C	40653	
VCA_COUNTS_AT_ZERO	Volt phase CA factory calibration setpoint	0x028D	40654	
IA_COUNTS_AT_ZERO	Current A factory calibration setpoint	0x028E	40655	

OUTPUT REGISTERS BLOCK 1

(READ OUTPUT REGISTERS = FUNCTION CODE 03)
(PRESET SINGLE REGISTER = FUNCTION CODE 06)
(PRESET MULTIPLE REGISTERS = FUNCTION CODE 16)

(V =Vortex, E =Electrospeed, T =Tracker)

IB_COUNTS_AT_ZERO	Current B factory calibration setpoint	0x028F	40656	
IC_COUNTS_AT_ZERO	Current C factory calibration setpoint	0x0290	40657	
ANALOG1_COUNTS_AT_ZERO	Analog input 1 factory calibration setpoint	0x0291	40658	
ANALOG2_COUNTS_AT_ZERO	Analog input 2 factory calibration setpoint	0x0292	40659	

OUTPUT REGISTERS BLOCK 2

(READ OUTPUT REGISTERS = FUNCTION CODE 03)
(PRESET SINGLE REGISTER = FUNCTION CODE 06)
(PRESET MULTIPLE REGISTERS = FUNCTION CODE 16)

(V =Vortex, E =Electrospeed, T =Tracker)

ANALOG1_LO_THLD_BP_DELAY	Analog 1 Low Threshold Bypass time delay	0x0300	40769	
ANALOG1_LO_THLD_SD_DELAY	Analog 1 Low Threshold shutdown time delay	0x0301	40770	
ANALOG2_HI_THLD	Analog Input 2 high alarm threshold	0x0302	40771	
ANALOG2_HI_THLD_BP_DELAY	Analog 2 high threshold Bypass time delay	0x0303	40772	
ANALOG2_HI_THLD_SD_DELAY	Analog 2 high threshold shutdown time delay	0x0304	40773	
ANALOG2_LO_THLD	Analog Input 2 low alarm threshold	0x0305	40774	
ANALOG2_LO_THLD_BP_DELAY	Analog 2 low threshold Bypass time delay	0x0306	40775	
ANALOG2_LO_THLD_SD_DELAY	Analog 2 low threshold shutdown time delay	0x0307	40776	
EXTERNAL_RESETS	Microprocessor Reset Status Register	0x0308	40777	
POWER_UP_RESETS	Microprocessor Reset Status Register	0x0309	40778	
LOSS_OF_CLOCK_RESETS	Microprocessor Reset Status Register	0x030A	40779	
BUS_ERROR_RESETS	Microprocessor Reset Status Register	0x030B	40780	
ILLEGAL_INST_RESETS	Microprocessor Reset Status Register	0x030C	40781	
DIV_BY_ZERO_RESETS	Microprocessor Reset Status Register	0x030D	40782	
SECURITY_JUMPER_IN_PLACE	Electrospeed security jumper status	0x030E	40783	E
KEYPAD_INVERT_FREQ	Frequency setpoint	0x030F	40784	E
REAL_TIME_DAY_OF_WEEK	Day of the week in numbers: Sunday = 1	0x0310	40785	
REAL_TIME_SECONDS	Real time clock's seconds value	0x0311	40786	
REAL_TIME_MINUTES	Real time clock's minutes value	0x0312	40787	
REAL_TIME_HOURS	Real time clock's hours value	0x0313	40788	
REAL_TIME_DATE	Real time clock's date value	0x0314	40789	
REAL_TIME_MONTH	Real time clock's month value: Jan = 1	0x0315	40790	
REAL_TIME_YEAR	Real time clock's year value	0x0316	40791	
ROTATION	Rotation alarm setpoint	0x0317	40792	
FIRST_LAST_SD	VMC-100 compatibility : cause of last shutdown	0x0318	40793	
SECOND_LAST_SD	VMC-100 compatibility : cause of 2 last shutdown	0x0319	40794	
THIRD_LAST_SD	VMC-100 compatibility : cause of 3 last shutdown	0x031A	40795	
FOURTH_LAST_SD	VMC-100 compatibility : cause of 4 last shutdown	0x031B	40796	
FIFTH_LAST_SD	VMC-100 compatibility : cause of 5 last shutdown	0x031C	40797	
ACCEL_FOR60_HZ	Time to accelerate output frequency by 60 Hz.	0x031D	40798	E
DECCEL_FOR60_HZ	Time to decelerate output frequency by 60 Hz.	0x031E	40799	E
VOLTS_AT60_HZ	Voltage at 60Hz setpoint	0x031F	40800	E
RATED_I	Rated output current for present model number	0x0400	40801	E
REGULATOR_GAIN	Regulator gain percentage	0x0401	40802	E

OUTPUT REGISTERS BLOCK 2

(READ OUTPUT REGISTERS = FUNCTION CODE 03)
(PRESET SINGLE REGISTER = FUNCTION CODE 06)
(PRESET MULTIPLE REGISTERS = FUNCTION CODE 16)

(V =Vortex, E =Electrospeed, T =Tracker)

RUNNING_ILIMIT	Current limit while running	0x0402	40803	E
SYNC_DELAY	Frequency sync. Time delay	0x0403	40804	E
SYNC_FREQUENCY_SETPOINT	Frequency sync. setpoint	0x0404	40805	E
SYNC_ILIMIT	Current limit during sync. delay	0x0405	40806	E
HIGH_SPEED_CLAMP	Maximum frequency permitted	0x0406	40807	E
PCM_INVERTER_MODE_STPNT	Power Conversion Module Inverter mode	0x0407	40808	E
PCM_CONVERTER_MODE_STPNT	Power Conversion Module Converter mode	0x0408	40809	E
LOW_SPEED_CLAMP	Minimum frequency permitted	0x0409	40810	E
INVERTER_PID_CNTRL_MODE	Inverter PID controller mode.	0x040a	40811	E

APPENDIX J: USER PROGRAMMABLE LOGIC

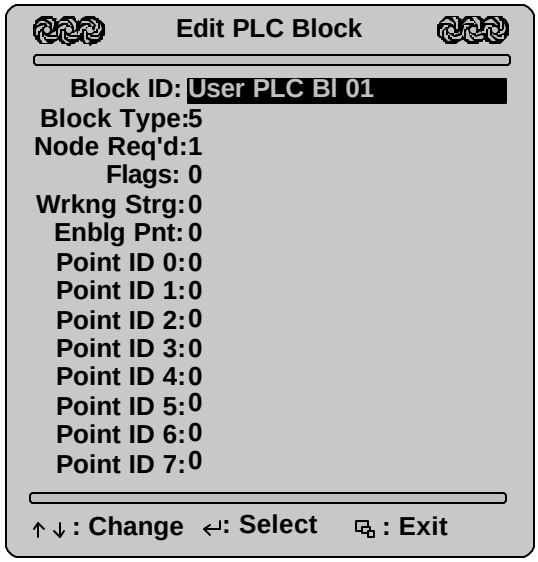
Introduction

The GCS family of control products allows the user to configure and code some types of algorithms that are not included in the standard product. These functions are collectively referred to by the general term of User Programmable Logic Control or User PLC. The User PLC functions are all based on the concept of utilizing a general purpose database structure to contain the user's variables and required functions in a database point memory variable array. These database memory variable structures are referred to as User Points. The scheduling and control of which database points to process and when are administered by the User PLC Blocks. The following describes the structure of the two user PLC structures, a list of available functions with brief descriptions, some term definitions and sample functions.

User PLC Block

All 48 User PLC Control Blocks within a GCS controller have the same array structure and contain the same number and types of elements. The User PLC Control Block structure is illustrated below.

```
User PLC_Block =
{
        blockId
        blockType
        nodeRequired
        flags
        workingStorage
        enablingPoint
        pointIds {
                PointId 0
                PointId 1
                PointId 2
                PointId 3
                PointId 4
                PointId 5
                PointId 6
                PointId 7
                }
}
```

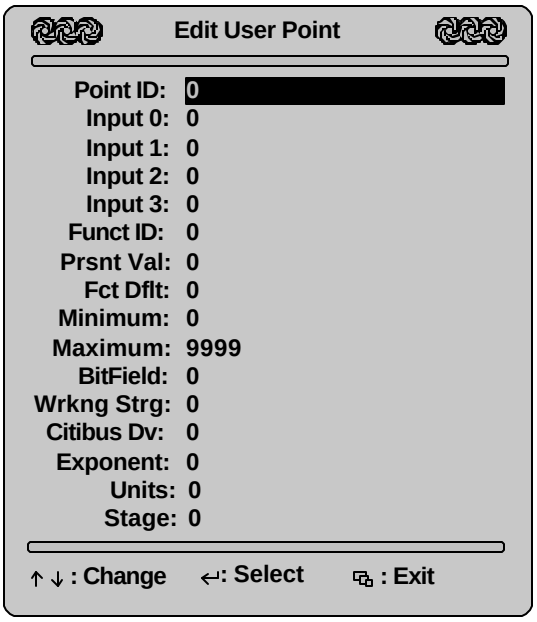


USER PLC Database

All of the 255 User PLC database points available in a GCS controller have the same array structure and contain the same number and types of elements. The user PLC data point structure is described below.

User PLC Database point identifier numbers (PointIds) are a pointer to a memory array. Each point contains these array members:

User PLC database point =
{
PointId inputs {
PointId Input [0]
PointId Input [1]
PointId Input [2]
PointId Input [3]
}
Function ID #
Present Value
Factory Default
PV Maximum
PV Minimum
Bit Field
Work Storage
Citibus Device
Exponent
Units
Execution Stage
}



User PLC Function Codes

The GCS controller provides several mathematical, Boolean and timing functions. The ID numbers of the functions and a description of their setups and operation are listed below.

ID number	Function		ID number	Function
14	AND		27	ONE SHOT TIMER
15	AVERAGE		28	INVERTER
16	COMPARE		29	PULSE GENERATOR
17	COPY PRESENT VALUE		30	IF THEN ELSE
18	CHECK ALARM		31	ADD
19	HIGH THRESHOLD		32	SUBTRACT
20	LOW THRESHOLD		33	MULTIPLY
21	MAXIMUM		34	DIVIDE
22	MINIMUM		35	SQUARE ROOT
23	TIMER		36	OR
24	TIMER CHECK		37	GENERIC PID CONTROL FUNCTION
25	HOLDBACK TIMER CHECK		38	LATCH
26	OUT OF BAND			

14: and

The present value of the database point named in the Input[0] field is logically “and-ed” with the present value of the database point named in the Input[1] field. The result is stored in the present value field of this database point

Present Value of this point = “Present Value of Input[0]” & “Present Value of Input[1]”

15 average

The present value of the database points named in the four input fields are added together, then the result is divided by the total number of valid input points. The result is stored in the present value field of this database point. If less than four input values are used, this function will use only the present values of the input database points that do not contain the null character.

$$\text{Present Value of this point} = \frac{(\text{PV of Input[0]}) + (\text{PV of Input[1]}) + (\text{PV of Input[2]}) + (\text{PV of Input[3]})}{\text{Number of non-null, valid inputs}}$$

16 compare

This function compares the present values of the two data points named in the input[0] and input[1] fields. If the two value are equal, the present value of this data point is set to TRUE (1). If the two values are not equal, the present value of this point is set to FALSE (0).

Present Value of this point = TRUE (1) if (PV of Input[0]) == (PV of Input[1])
Present Value of this point = FALSE (1) if (PV of Input[0]) != (PV of Input[1])

17 CopyPresentValue

This function copies the present value of the data point named in the input[0] field to the present value of the data point named in the input[1] field.

Present Value of Input[1] = Present Value of Input[0]

18 checkAlarm
Not available in this release

19 High Threshold
This function HiThreshold accepts two analog input values from the present value of database points named in the field, input[0] and input[1] and compares the two values. Input[0] is the value and input[1] is the threshold.

If input[0]<= input[1] the threshold has not been exceeded, Present value == FALSE.
If input[0]> input[1] the threshold has been exceeded, Present Value == TRUE.

20 Low Threshold
This function Low Threshold accepts two analog input values from the present value of database points named in the field, input[0] and input[1] and compares the two values. Input[0] is the value and input[1] is the threshold.

If input[0] >= input[1] the threshold has not been exceeded, Present value == FALSE.
If input[0] < input[1] the threshold has been exceeded, Present Value == TRUE.

21 Maximum

This function compares the present value of the database points named in input[ ] fields and copy the largest of the values to the present value field of this point.

Present Value of this point = the greater of input[0], input[1], input[2] and input[3]

22 Minimum

This function compares the present value of the database points named in input[ ] fields and copy the smallest of the values to the present value field of this point.

Present Value of this point = the lesser of input[0], input[1], input[2] and input[3]

23 Timer

Not available in this release

24 Timer Check

Not available in this release

25 Holdback Timer Check

Not available in this release

26 Out of Band

This function compares the present value of the database point identified by input[0] to the low threshold limit in input[1] and to the high threshold limit in input[2]. If either threshold is exceeded, the present value of this point is set to TRUE (1) else it is set to FALSE (0)

If Pvalue of input[0] < input[1] or input[0] > input[2] then this point == TRUE
If Pvalue of input[0] => input[1] or input[0] <= input[2] then this point == FALSE

27 One Shot Timer

Not available in this release

28 Inverter

This function will read the Present value of the database point identified by input[0] and set the present value of this point to the inverted value.

If Pvalue of Input[0] == 0, then Pvalue of this point == 1
If Pvalue of Input[0] == 1, then Pvalue of this point == 0

29 Pulse Generator

Not available in this release

30 If Then Else

This conditional function will allow the user to execute one set of instructions if the condition is true or a different set of instructions if the condition is false.

The function accepts four inputs that are defined as:

input[0] = point ID of first value to compare
input[1] = point ID of second value to compare
input[2] = User PLC Block ID of PLC block to enable if condition is TRUE
input[3] = User PLC Block ID of PLC block to enable if condition is FALSE

If Pvalue of input[0] = input[1] then enable PLC Block ID identified in input[2],

disable PLC Block ID identified in input[3]

If Pvalue of input[0] != input[1] then enable PLC Block ID identified in input[3]
disable PLC Block ID identified in input[2]

31 Add

This function will arithmetically add the present value of the database points identified by input[0] and input[1]. The result is stored in the present value of this point. All values and results are integers.

PresentValue = (Pvalue of input[0]) + (Pvalue of input[1])

32 Subtract

This function will arithmetically subtract the present value of the database point identified by input[1] from the present value of input[0]. The result is stored in the present value of this point. All values and results are integers.

PresentValue = (Pvalue of input[0]) - (Pvalue of input[1])
When the result is negative, the value will rail to 9999

33 Multiply

This function will arithmetically multiply the present value of the database point identified by input[1] with the present value of input[0]. The result is stored in the present value of this point. All values and results are integers.

PresentValue = (Pvalue of input[0]) * (Pvalue of input[1])
Maximum result value is 9999

34 Divide

This function will arithmetically divide the present value of the database point identified by input[0] with the present value of input[1]. The result is stored in the present value of this point. All values and results are integers. If a divide function results in a fractional number, the result is rounded down to the nearest integer value.

PresentValue = (Pvalue of input[0]) / (Pvalue of input[1])

35 Square Root

This function will derive the square root of the present value of the database point identified by input[0]. The result is stored in the present value of this database point. All values and results are integers.

PresentValue = Square Root (Pvalue of input[0])

36 Or

This function will logically OR up to four inputs identified by input[0], input[1], input[2] and input[3].
The result is stored in the present value of this data base point.

PresentValue = (PV-input[0]) or (PV-input[1]) or (PV-input[2]) or (PV-input[3])

37 User Control Function

Not available in this release

38 Latch Function

Not available in this release

User Point Bitfield Codes
The Bitfield variable contained in the user database point can set the following definitions.

READ_ONLY The presentValue is read-only, i.e. may not be altered via the display
#define READ_ONLY ((unsigned short)0x0001)

DISCRETE The presentValue is discrete (on/off or true/false)
#define DISCRETE ((unsigned short)0x0002)

MAY_BE_LOGGED Point may be logged to PC card on display
#define MAY_BE_LOGGED ((unsigned short)0x0004)

REVERSE The discrete value is reverse acting
#define REVERSE ((unsigned short)0x0008)

MAX_IS_POINT The maximum value is defined by the point stored in Point.maximum.id. Otherwise the maximum is stored in Point.maximum.value
#define MAX_IS_POINT ((unsigned short)0x0010)

MIN_IS_POINT The minimum value is defined by the point stored in Point.minimum.id. Otherwise the minimum is stored in Point.minimum.value
#define MIN_IS_POINT ((unsigned short)0x0020)
#define NORMAL_STATE ((unsigned short)0x0040

SETPOINT The FLASH copy of the database point should be updated.
#define SETPOINT ((unsigned short)0x0080)

NOTIFY_REMOTE_ON_CHANGE Changes to the present value of the point should be shipped to CITIBus module specified in citibusDevice field of the point.
#define NOTIFY_REMOTE_ON_CHANGE ((unsigned short)0x0100)

PRESENT_VALUE_IS_SCALED Value in presentValue offset is to be multipled by 10** the number in the decimalExponent offset.3

#define PRESENT_VALUE_IS_SCALED ((unsigned short)0x0200)

ACCESS_CONTROL_BIT1
ACCESS_CONTROL_BIT2
A two bit field indicating what security level the user must be at in order to change the present value of the point. Normally applied to setpoints.

#define ACCESS_CONTROL_BIT1 ((unsigned short)0x0400)
#define ACCESS_CONTROL_BIT2 ((unsigned short)0x0800)

SKIP_EVENT_LOGGING Changes to the point are not written to into event records buffer.
#define SKIP_EVENT_LOGGING ((unsigned short)0x1000)

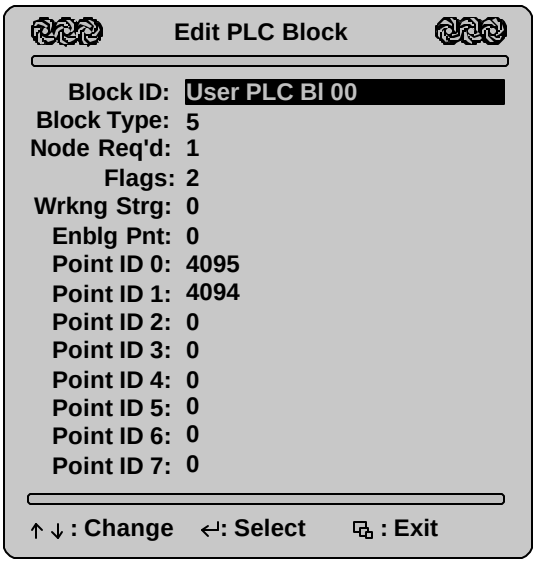
ADD_POINT_TO_ALARM_LIST Point Id is added to be added to list of things causing an alarm
#define ADD_POINT_TO_ALARM_LIST ((unsigned short)0x2000)

REMOTE_UPDATE_PENDING Exchange of changed present value is in progress. This bit is set/cleared dynamically.
#define REMOTE_UPDATE_PENDING ((unsigned short)0x8000)

User PLC Example Algorithms

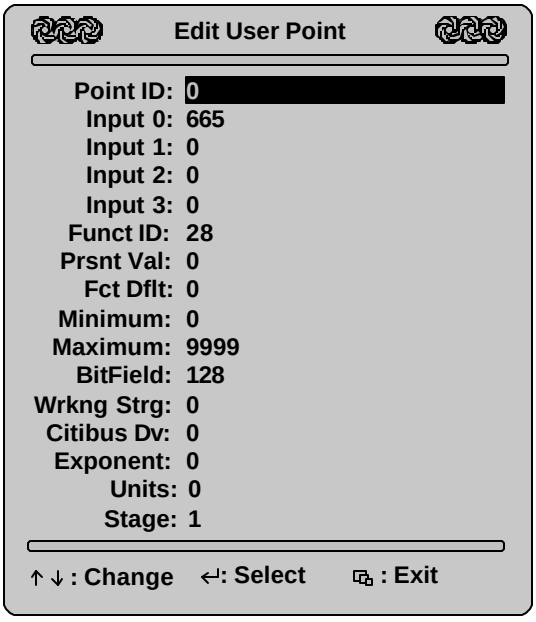
Remote Start Switch via Digital Input on I/O module

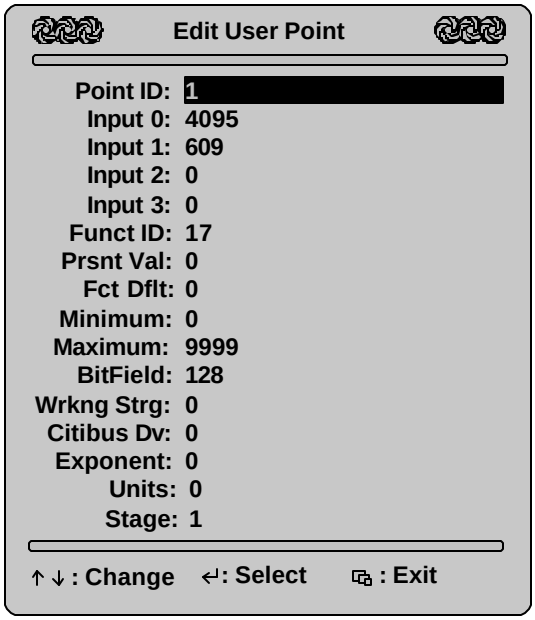
This example User PLC routine will use a digital input from an I./O expansion module as a remote start switch. To use this algorithm, enter the data in these tables into User PLC Block 0, User Point 0 and 1.



To use a different I/O Module or Digital Input, substitute the input0: value (665) of User point 0 with one of the following:

Database Point	Point ID
IO1-DI1	665
IO1-DI2	669
IO1-DI3	673
IO2-DI1	700
IO2-DI2	704
IO2-DI3	708
IO3-DI1	735
IO3-DI2	739
IO3-DI3	743

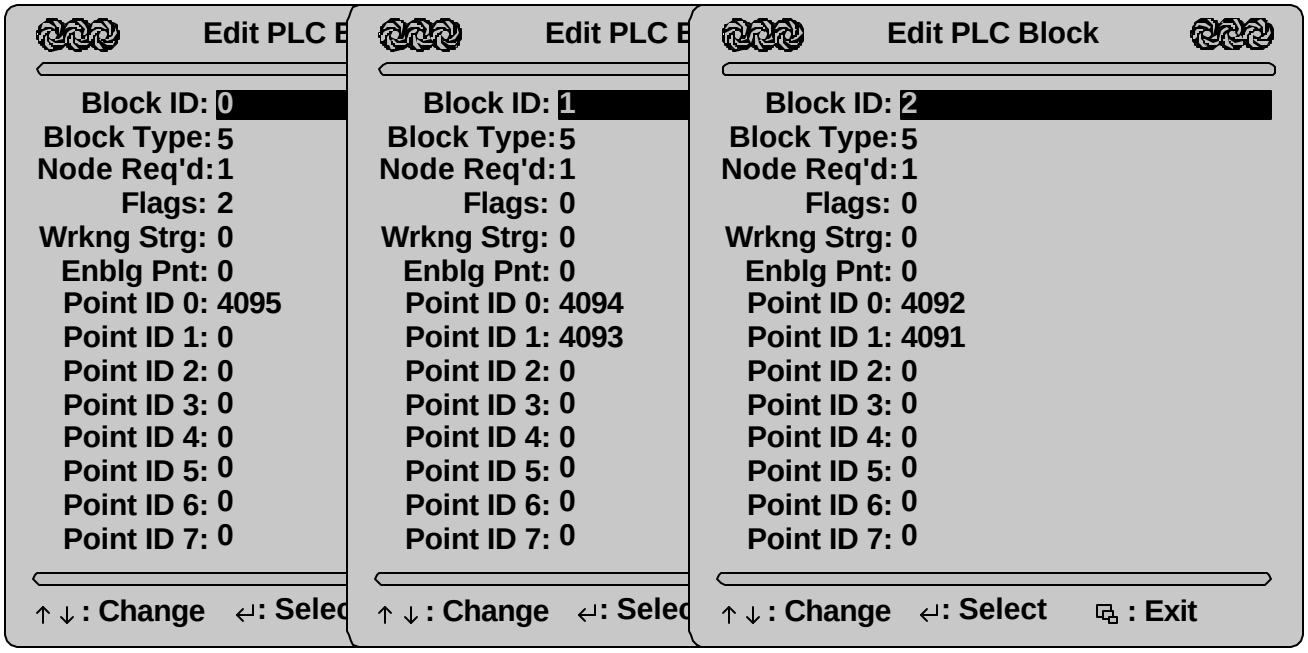


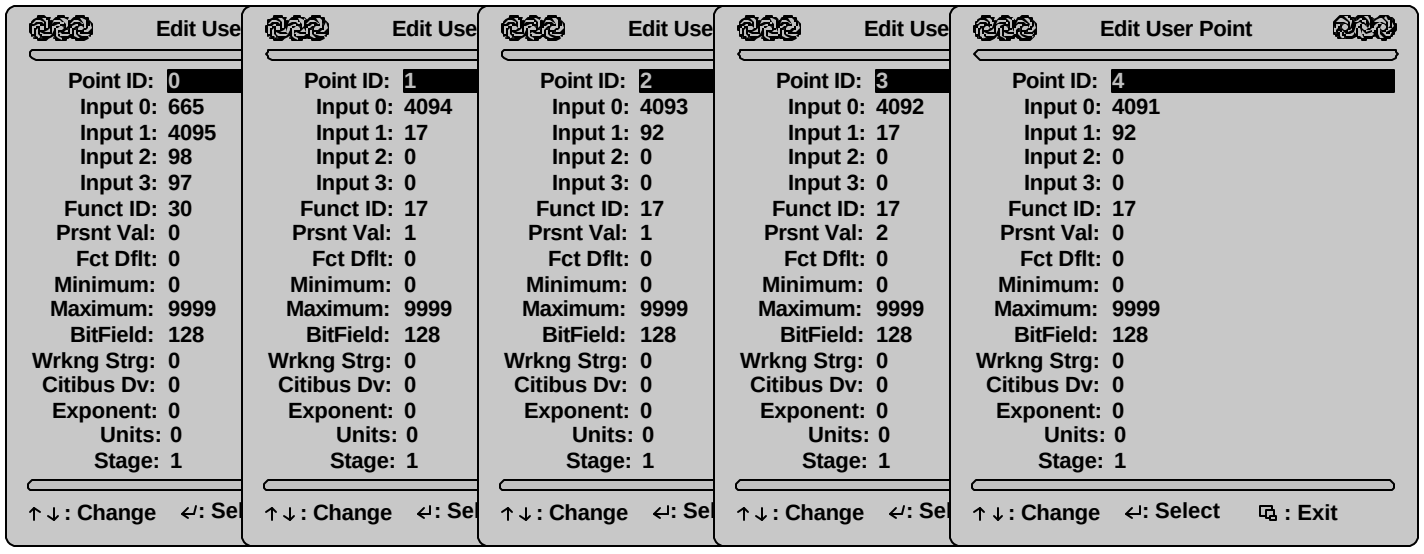


Remote Emergency STOP Switch via Digital Input on I/O module

This example User PLC routine will use a digital input from an I./O expansion module as a remote Emergency Stop switch. To use this algorithm, enter the data from these tables into User PLC Block 0,1 & 2, and User Points 0, 1, 2, 3 and 4.

If IO1DI1 =1, set PCM Stop Mode to E-Stop & issue Central Shutdown command.
If IO1DI1 =0, set PCM Stop Mode to Coast & clear Central Shutdown command.





Appendix K: Use of the PCMCIA Card

Introduction

The Graphic Control System (GCS) line of Centrilift Controls products provides advanced historical data logging capabilities to the user. This historical information will help to diagnose equipment problems, extend runlife, and analyze production information. Several types of historical information are available:

- An Event history log stores all system events such as power up, parameter changes and alarms. These events are date and time stamped, with a record of 'before' and 'after' parameter values.
- A Historical Shutdown log stores the cause and datestamp of the last 99 shutdowns.
- An on board digital ampchart that samples Ampchart Phase B every 100 ms and stores the Min / Max and Average every 4 minutes replaces the standard paper ampchart and ensures that the last 7 days of data is always available for viewing.
- On the Centrilift Electrostart switchboard running a GCS Vortex motor protection & control unit, a startup waveform that details the 3 phase Voltage and Current waveforms during a cross the line start. The first two seconds of the last startup are sampled at 600 samples per second, producing an informative set of waveforms for analysis and troubleshooting.
- Built in datalogging functionality allows up to 12 system parameters (volts, amps, I/O, frequency) to be logged as fast as once per second with the use of external PC Card ATA flash disks.

To facilitate the transfer and logging of this historical information, the GCS products incorporate a PCMCIA card slot. The PCMCIA slot accepts type I or II PC Card ATA Flash cards. Currently 8 Megabyte ATA PC Cards from two different vendors have been approved for used, and other sizes and manufacturers cards are being tested for compatibility and reliability.

The Centrilift part number: 900608 designates the approved 8MB PC Card ATA flash card, with industrial specifications (-40 to +85 operating).

II. Inserting the PC Card into the Graphic Display

a. Orientation

The PC Card slot is located on the top right side of the GCS Graphic Display. (See below)

The initial production of Graphic display boards had a slot which required the PC Card to be inserted 'upside down' relative to the front of the display. Most production models of this version will have a label below the PC Card slot that indicates this.

The latest production version of Graphic Display units require the PC Card to be inserted 'right side up' a more natural orientation.

In either case, the PC Card slot is keyed, such that if the card is inserted incorrectly, it will only slide in about ¾ of the way into the slot. In the proper orientation, the card will slide in all the way into the slot and require only a small amount of force to complete the electrical insertion.

NOTE: The PC Card COU LD be pushed into the slot incorrectly if excessive force is used. The general rule is that if the card slides more than ¾ of the way into the slot without any major obstruction, it is oriented correctly.

b. Recognition of PC Card on the Graphic Display

Once the PC Card is inserted into the Graphic Display, a dialog box will appear indicating that the PC Card insertion was noted, and the software will test the card for compatibility and functionality.

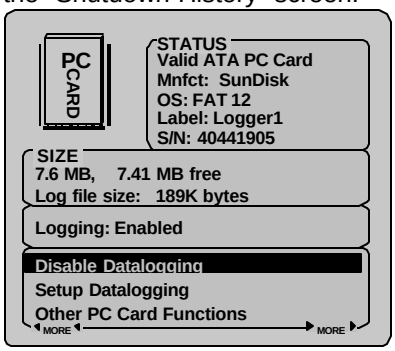
If the PC Card tests OK, the dialog will be closed. At this point, the PC Card is ready for use, as described in section III & IV. If the user had previously 'Enabled' the Datalogging feature, a second dialog indicating that Datalogging was starting would be displayed. This dialog would also close automatically.

If any problems exist with the card, an error message will be displayed. Consult section "VI Troubleshooting" for error message explanations.

c. Accessing PC Card features

The PC Card features are accessed from the GCS Operating system via the PC Card Status screen. The steps to access this screen are as follows:

1. Start at the Main Menu – If the main menu is not displayed, simply press the "MENU" key several times until the group of 9 main menu options is visible.
2. Using the arrow keys, move the cursor to the 'Datalog & History' option, and press the "ENTER" key.
3. The screen display could be one of many, but will normally be the "Shutdown History" screen.
4. Press the Left arrow key 2 times. This will display the PC Card STATUS screen, which details similar information to that shown in the dialog that was displayed when the PC Card was first inserted. (If you did not originally see the 'Shutdown History" menu, keep pressing the 'Menu' key until the PC Card STATUS screen is displayed.)

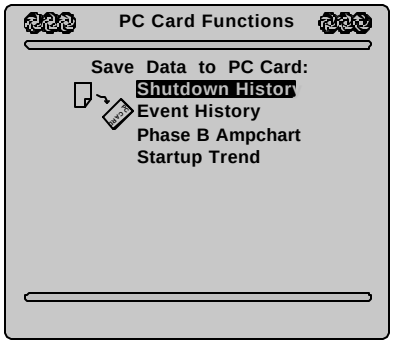


III. Writing Historical Data to the PC Card

All the major historical databases can be stored as files on the PC Card for analysis on a laptop or desktop computer. The information is stored as a Comma Separated Variable (CSV) file. This is simply an ASCII test file formatted with comma's between the data fields of a record. This method of storage was chosen to avoid any proprietary file structures that would need a special driver or software interpolation program to read. Additionally, the CSV files are recognized by most spreadsheet programs (Lotus, Excel, Quattro etc.) and are automatically converted to table data when loaded.

NOTE: The Datalogging function of the GCS Display must be disabled (see section IV) to perform the following tasks.

a. Accessing the "Other PC Cards Screen"



To save the historical databases to files on the PC Card, the user must use the "Other PC Card Functions" screen. From the PC Card STATUS screen (see II- C above) use the arrow keys to highlight and select the option "Other PC Card Functions"

b. Saving the Shutdown History to the PC Card

The causes of the last 99 shutdowns with date and time stamping can be written to the PC Card by selecting the *Shutdown History* option on the *Other PC Card Functions* screen. This will create a CSV file named 'SDHIST.CSV' on the PC Card.

c. Saving Event History to the PC Card

The list of 255 recent system events, including data and time stamping can be written to the PC Card by selecting the *Event History* option on the *Other PC Card Functions* screen. This will create a CSV file named *EVENTS.CSV* on the PC Card.

d. Saving Phase B Digital Ampchart to the PC Card

The digital ampchart data representing the Phase B amperage recorded for the last week of runtime, including data and time stamping can be written to the PC Card by selecting the *Phase B Ampchart* option on the *Other PC Card Functions* screen. This will create a CSV file named *AMPCHART.CSV* on the PC Card. This is a large file and may take up to 1 minute to complete the save to disk.

e. Saving the last Startup Waveforms to the PC Card

For GCS Vortex equipped switchboards, the option *Startup Trend* will appear on the *Other PC Card Functions* screen. Selecting this option will cause 1200 records of data for the 3 phase Voltage and 3 Phase Amperage recorded at the last startup to be saved to the PC Card. The name of this file will be *STARTUP.CSV*. It may take 30 seconds or more to create this file.

In all of the cases above, a window opens when the write process begins indicating the progress of the file write operation. When this dialog window closes, the file on the disk has been closed and it is safe to remove the PC Card from the slot.

IV. Setup and Enable Datalogging

The datalogging capabilities of the GCS products are designed to allow long term historical trending of operational data. A total of 12 system parameters can be logged at a variable sample rate. The maximum sample rate is 1 sample per second. The data is stored to the PC Card ATA flash disk using the GCS display. The number of samples available is limited only by disk space.

a. How long can the PC Card log data before it is full?

The PC Card we have set up in inventory is 8 megabytes (MB) in size. A typical 8 MB card has 7,956,480 bytes (a.k.a. characters) available for use after the disk is formatted. We are testing with cards up to 32 MB but have not released them for use yet. Each sample taken uses 33 bytes (characters) of space. As the time between samples decreases, the data cards will fill up faster. Typical sample times are expected to be in the range from 1 minute to 1 hour.

Some sample calculations of memory space usage might be as follows:

Example #1 *- 12 parameters sampling once each hour:*
Each hour we would use 33 bytes x 12 samples = 396 bytes
Each day we would use 396 * 24 = 9504
We could sample at this rate for 7956480 / 9504 = 837 days.

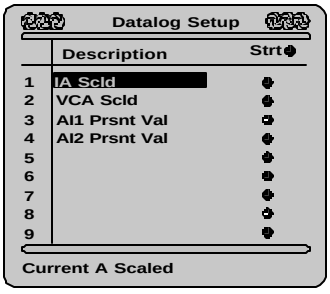
Example #2 *- 6 parameters sampling once each minute:*
Each hour we would use 60 * 33 * 6 = 11880 bytes.
Each day we would use 11880 * 24 = 285120
We could sample at this rate for 7956480 / 276480 = 28 days.

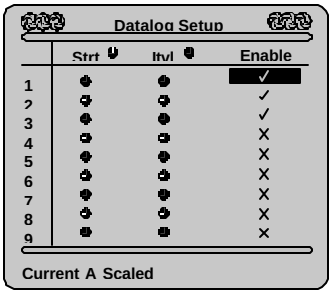
Example #3 *- 3 parameters sampling 1 sample per second:*
Each second we would have 33 * 3 bytes used = 99 bytes.
Each hour would consume 99 * 3600 = 356400
We could sample at this rate for 7956480 / 345600 = 22 hours.

b. Set Up Parameters to be Logged

The setup of parameters to be logged and the interval between samples is handled on the Datalog Setup screen. This screen is accessed by selecting the *Setup Datalogging* option from PC Card Status menu.(see section IIc)

NOTE: The Setup Datalogging screen cannot be accessed while datalogging is in progress.





Ensure datalogging is disabled before attempting to access this screen.

The Setup Datalogging screen is arranged in 4 columns:

Description – This is where the system parameter to be logged is selected and the description of the system parameter will be located here. To select a desired parameter, position the cursor in the *Description* column at the desired row and press the *ENTER* key. If not parameter was previously listed, the description for the first available parameter will be displayed. Using the up and down cursor keys, scroll through the list of parameters available until the desired parameter is found. Then press the *ENTER* key again to save the parameter for logging.

Start Time – This column is reserved for future development.

Interval Time – This column is where the time (in seconds) between samples is entered. Once the desired parameter has been chose as above, position the cursor in the Interval Time column for the row the selected parameter is in. Then press the *ENTER* key to edit the time. Initially the lower portion of the screen will indicate 'Not Configured'. The time is entered in seconds from 0 to 9999. Once the desired seconds are entered using the arrow keys, press *ENTER* to save the

value. Notice that the interval time, in hours, minutes, seconds is displayed at the bottom of the screen.

Enable – This column indicates whether the selected system parameter is currently enabled for logging or not. Once a parameter has been selected in column 1 and a desired sampling interval has been entered in column 3, the parameter must be enabled for datalogging. This is accomplished by positioning the cursor over the Enable column for the desired row and pressing the *ENTER* key to edit the *log status* of the parameter. Using the arrow keys, set the parameter to be enabled (✓) or disabled (✗).Then press the *ENTER* key to accept the change.

c. Enable / Disable data logging

Once the system parameters to be logged are setup, the user need only insert a valid ATA PC Card into the PC Card slot and select the Enable Datalogging parameter from the *PC Card Status* menu.

If the PC Card is valid and the parameter setup is correct, a dialog box indicating that datalogging is starting will be displayed.

The PC Card datalogging features are designed to restart automatically if a power fail situation should occur. Once the datalogging is enabled, datalogging should continue until the user disables the logging, or the PC Card fills up, in which case the datalogging will be automatically disabled.

d. Disabling datalogging / removing the PC Card

To remove the PC Card the user MUST disable the datalogging feature in the PC Card Status menu. If the PC Card is removed without disabling datalogging, a warning dialog will pop up indicating that information loss or file corruption may occur if the card is not re-inserted.

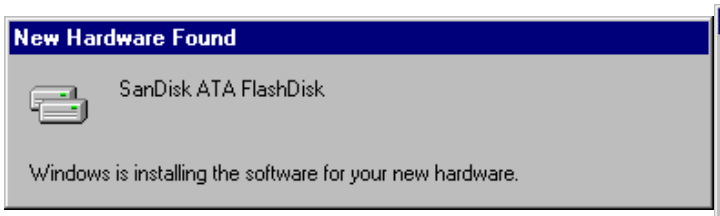
V. Using the PC Card in the Windows 95/98 PC

The PC Card ATA Flash disk is supported automatically by standard Windows 95 & 98 installations. When the PC Card is inserted into a PC with PCMCIA slots, the system recognizes the Flash disk as another system hard disk of size 8 Mb. This format of PC Card was chosen to allow the most widely installed base of computer systems to work seamlessly with the data from the GCS Products.

a. Insert the PC Card in a laptop PCMCIA slot.

When the PC Card is inserted into the PCMCIA slot on the computer for the first time, Windows will automatically detect the card and load the appropriate driver for use with the flash disk. Depending on the manufacturer of the PC Card, a screen similar to the screens depicted below will be displayed as windows prepares the card for system use.

Follow the instructions as indicated by Windows to complete the installation of the PC Card IDE driver. (This may require the computer to be restarted). Once the driver loading process is finished, the PC Card Flash disk should appear in the list of devices in the *My Computer* explorer window. (See next)



b. Open an Explorer window to view PC Card Contents

In most Windows computers there will be a *My Computer* icon in the upper left hand corner of the desktop. This icon will allow the display of the data storage devices that are available on the computer system. Selecting this icon (normally with a double-click action) will open a window that appears similar to the one below. In the list of Local Disks, there should be a new drive of size 7.57 MB (an 8 MB hard drive formatted).

c. Working with the PC Card files

The new PC Card drive (in this case drive d:) can be accessed just like any hard drive or floppy drive. Files can be copied to or from the drive, or opened right from the drive. If the user was to open the drive in a new explorer window by double-clicking on the new drive, a window that lists the files saved to the disk from the GCS Device will be displayed. The four files which may appear are:

1. log.csv – the datalog output file
2. sdhist.csv – the shutdown history output file
3. ampchart.csv – the digital ampchart output file
4. events.csv – the event history output file.
5. Trends.csv – the high speed startup trending output file (GCS Vortex only).

A more detailed description of these file contents was discussed in section III.

The CSV format as explained earlier is very versatile and as a result, if the computer has a spreadsheet program installed (Excel, Lotus, Quatro etc.) the user need only select one of the files and the tabular information will be imported into a spreadsheet form. These files are simple ascii text files which can be read and edited with most text editor utilities.

The Datalog output file (log.csv) will appear similar to the captured output below. Note that since the datalog file can be appended in multiple logging sessions, no header information is recorded, only the data records:

	A	B	C	D	E
1	67	4	7/13/00	15:07:54	S
2	67	4	7/13/00	15:07:55	
3	67	4	7/13/00	15:07:56	
4	67	4	7/13/00	15:07:57	
5	67	4	7/13/00	15:07:58	
6	67	4	7/13/00	15:07:59	
7	67	4	7/13/00	15:08:00	
8	67	4	7/13/00	15:08:20	
9	67	4	7/13/00	15:08:21	
10	67	4	7/13/00	15:08:22	
11	67	4	7/13/00	15:08:23	
12	67	4	7/13/00	15:08:24	
13	67	4	7/13/00	15:08:25	

The fields descriptions for each record are: (left to right)

Parameter ID, Value, Date, Time, Status field

The Parameter ID field is a number representing the parameter that was logged. The use of a number ID saves disk space over continually recording a long filename to disk. The Parameter description can be decoded using the table on the following page.

The Status field mainly contains a single character ‘S’ to indicate that datalogging was ‘STARTED’ at this sample.

Note that when multiple parameters are selected, the samples will be mixed together one after another. Sorting the file on the first column will allow each set of data for the specific parameter to be isolated and graphed.

Point ID descriptions for parameters that can be logged in GCS devices:

5	Electrospeed Output Frequency
6	Electrospeed Output Current Phase A
7	Electrospeed Output Current Phase B
8	Electrospeed Output Current Phase C
9	Electrospeed OutputVolts
42	Analog Input # 1 Present Value
67	Analog Input # 2 Present Value
97	Digital Input # 1 Present Status
109	Digital Input # 2 Present Status
125	Accumulated Gigawatt Hours
130	Vortex GCS / Input Current Phase A
132	Vortex GCS Input Volts CA Frequency
135	Vortex GCS / Input Current Phase B
139	Vortex GCS / Input Current Phase C
141	Present Amount of Current Unbalance
156	Accumulated Kilowatt Hours
157	Instantaneous Kilowatts
162	Accumulated Megawatt Hours
166	Highest Input Amperage Phase (Overload)
209	Measured Power Factor
259	Average 3 Phase Amperage (Underload)
271	Lowest Voltage Phase Reading (Undervolt)
285	Vortex GCS Voltage AB
289	Vortex GCS Voltage BC
294	Vortex GCS / Input Voltage Voltage CA
297	Present Amount of Voltage Unbalance
387	Electrospeed Heatsink 1 Temp
399	Electrospeed Heatsink 2 Temp
411	Electrospeed Heatsink 3 Temp
423	Electrospeed Heatsink 4 Temp
435	Electrospeed Inductor Temp
447	Electrospeed Ambient Temp
461	Electrospeed Aux Temp
566	Electrospeed Digital Input 3 Status
611	PCM (Electrospeed) DCLink Amps
612	Electrospeed Output Voltage AB Average
613	Electrospeed Output Voltage CA Average
614	Electrospeed Output IB Average
628	Serial Communication Status
665	Expansion I/O Module #1 - Digital Input #1 Status
668	Expansion I/O Module #1 - Digital Input #1 Pulse Accumulator
669	Expansion I/O Module #1 - Digital Input #2 Status
672	Expansion I/O Module #1 - Digital Input #2 PulseAcc
673	Expansion I/O Module #1 - Digital Input #3 Status
676	Expansion I/O Module #1 - Digital Input #3 Pulse Accumulator
686	Expansion I/O Module #1 - Analog Input #1 Fast Average
687	Expansion I/O Module #1 - Analog Input #1 Slow Average
689	Expansion I/O Module #1 - Analog Input #1 Maximum
690	Expansion I/O Module #1 - Analog Input #1 Minimum
691	Expansion I/O Module #1 - Analog Input #1 RMS
692	Expansion I/O Module #1 - Analog Input #2 Fast Average
693	Expansion I/O Module #1 - Analog Input #2 Slow Average
695	Expansion I/O Module #1 - Analog Input #2 Maximum
696	Expansion I/O Module #1 - Analog Input #2 Minimum
697	Expansion I/O Module #1 - Analog Input #2 RMS
700	Expansion I/O Module #2 - Digital Input #1 Status
703	Expansion I/O Module #2 - Digital Input #1 Pulse Accumulator
704	Expansion I/O Module #2 - Digital Input #2 Status
707	Expansion I/O Module #2 - Digital Input #2 PulseAcc
708	Expansion I/O Module #2 - Digital Input #3 Status
711	Expansion I/O Module #2 - Digital Input #3 Pulse Accumulator
721	Expansion I/O Module #2 - Analog Input #1 Fast Average
722	Expansion I/O Module #2 - Analog Input #1 Slow Average
724	Expansion I/O Module #2 - Analog Input #1 Maximum
725	Expansion I/O Module #2 - Analog Input #1 Minimum
726	Expansion I/O Module #2 - Analog Input #1 RMS
727	Expansion I/O Module #2 - Analog Input #2 Fast Average
728	Expansion I/O Module #2 - Analog Input #2 Slow Average
730	Expansion I/O Module #2 - Analog Input #2 Maximum
731	Expansion I/O Module #2 - Analog Input #2 Minimum
732	Expansion I/O Module #2 - Analog Input #2 RMS
735	Expansion I/O Module #3 - Digital Input #1 Status
738	Expansion I/O Module #3 - Digital Input #1 Pulse Accumulator
739	Expansion I/O Module #3 - Digital Input #2 Status
742	Expansion I/O Module #3 - Digital Input #2 PulseAcc
743	Expansion I/O Module #3 - Digital Input #3 Status
746	Expansion I/O Module #3 - Digital Input #3 Pulse Accumulator
756	Expansion I/O Module #3 - Analog Input #1 Fast Average
757	Expansion I/O Module #3 - Analog Input #1 Slow Average
759	Expansion I/O Module #3 - Analog Input #1 Maximum
760	Expansion I/O Module #3 - Analog Input #1 Minimum
761	Expansion I/O Module #3 - Analog Input #1 RMS
762	Expansion I/O Module #3 - Analog Input #2 Fast Average
763	Expansion I/O Module #3 - Analog Input #2 Slow Average
765	Expansion I/O Module #3 - Analog Input #2 Maximum
766	Expansion I/O Module #3 - Analog Input #2 Minimum
767	Expansion I/O Module #3 - Analog Input #2 RMS
770	Tracker Channel 1
771	Track Channel 2
772	Track Channel 3
773	Track Channel 4
774	Track Channel 5
775	Track Channel 6
842	Track Channel 7
843	Track Channel 8
844	Tracker Channel 1 Raw
845	Tracker Channel 2 Raw
846	Tracker Channel 3 Raw
847	Tracker Channel 4 Raw
848	Tracker Channel 5 Raw
849	Tracker Channel 6 Raw
850	Tracker Channel 7 Raw
851	Tracker Channel 8 Raw
1192	Expansion I/O Module #1 - Analog Output # 1
1196	Expansion I/O Module #1 - Analog Output # 2
1200	Expansion I/O Module #2 - Analog Output # 1
1204	Expansion I/O Module #2 - Analog Output # 2
1208	Expansion I/O Module #3 - Analog Output # 1
1212	Expansion I/O Module #3 - Analog Output # 2

An example of the shutdown history file that was loaded into Excel is shown below:

Microsoft Excel - Sdhist.csv

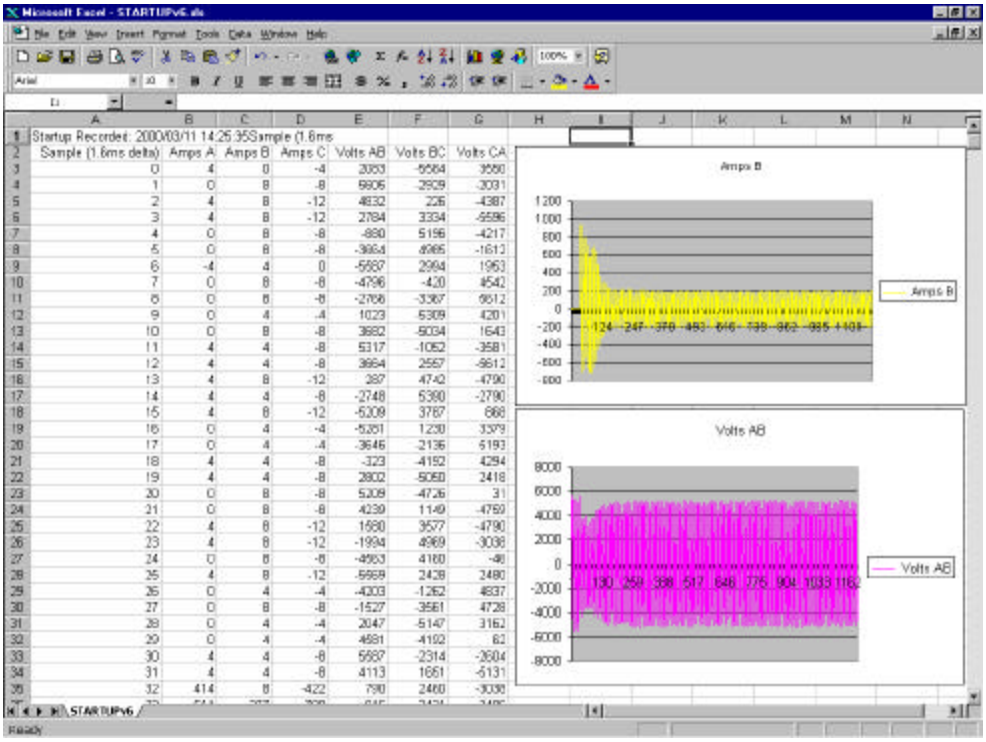
	A	B	C
1	Shutdown Cause	Timestamp	
2	Digital input 2	2000/02/24	03:06:59
3	Digital input 2	2000/02/24	02:09:16
4	Power fail	2000/01/14	15:06:20
5	Power fail	2000/01/13	10:22:33
6	Under voltage	2000/01/13	09:24:41
7	Underload	2000/01/13	08:22:28
8	Overload Lk	2000/01/13	08:20:51
9	Current Unbalance	2000/01/13	08:19:26
10	Over voltage	2000/01/13	08:17:57
11	Voltage Unbalance	2000/01/13	08:06:38
12	Voltage Unbalance	2000/01/13	08:05:12
13	Voltage Unbalance	2000/01/13	08:04:30
14	Voltage Unbalance	2000/01/13	08:02:00
15	Over voltage	2000/01/13	08:01:36
16	Manual Kpad Sd	2000/01/13	08:00:46
17	Rotation	2000/01/13	07:44:10
18			
19			
20			
21			

Note that a column heading indicates the type of data in each column.
The second example, shown below is an event log file from this disk.

Microsoft Excel - Events.csv

	A	B	C	D	E	F	G
1	Event Id	Event Type	Related Point	Date	Time	Before	After
2	0	Change from normal	Digital input 2	2000/03/11	13:57:15		
3	1	Shutdown	Hand-off-auto Switch	2000/03/11	13:57:12		
4	2	Setpoint change	Underload Alarm Enable	2000/03/11	13:55:48	1	0
5	3	Setpoint change	Voltage Unbalance Alarm Enable	2000/03/11	13:34:00	0	1
6	4	Setpoint change	Under voltage Alarm Enable	2000/03/11	13:33:50	0	1
7	5	Setpoint change	Under voltage Setpoint	2000/03/11	13:33:45	3430	3360
8	6	Setpoint change	Over voltage Alarm Enable	2000/03/11	13:33:23	0	1
9	7	Setpoint change	Current Unbalance Alarm Enable	2000/03/11	13:33:11	0	1
10	8	Setpoint change	Current Unbalance Setpoint	2000/03/11	13:33:05	800	600
11	9	Setpoint change	Underload Setpoint	2000/03/11	13:32:11	84	98
12	10	Setpoint change	Overload Setpoint	2000/03/11	13:31:45	215	140
13	11	Return to normal	Overload	2000/03/11	14:25:35		
14	12	Return to normal	Underload	2000/03/11	13:25:35		
15	13	Change from normal	Overload	2000/03/11	13:25:35		
16	14	Change from normal	Underload	2000/03/11	13:25:35		
17	15	Startup		2000/03/11	13:25:35		
18	16	Return to normal	Zero crossing Alarm	2000/03/11	13:02:02		
19	17	Return to normal	Digital input 2	2000/03/11	13:02:02		
20	18	Return to normal	Digital input 1	2000/03/11	13:02:02		
21	19	Initial program load		2000/03/11	13:02:01		
22	20	Change from normal	Zero crossing Alarm	2000/03/11	12:59:44		
23	21	Change from normal	Digital input 2	2000/03/11	12:59:44		
24	22	Change from normal	Digital input 1	2000/03/11	12:59:44		
25	23	Setpoint change	Voltage AB Scaler	2000/03/11	12:15:08	5095	4589
26	24	Return to normal	Zero crossing Alarm	2000/03/11	13:13:31		
27	25	Return to normal	Digital input 2	2000/03/11	12:13:31		
28	26	Return to normal	Digital input 1	2000/03/11	12:13:31		
29	27	Initial program load		2000/03/11	12:13:30		

Finally, an example of the startup trending history, which was loaded and then graphed using the chart wizard features of Excel is shown here:



VI. Troubleshooting PC Card Problems

The following question & answer guide should be used as a first step in solving PC Card problems with the GCS Display.

a. Problems using the PC Card with the GCS Display.

1. I insert the PC Card into the GCS Display and get a message that says: "Disk Error" or "File Access Error":

The GCS PC Card software is designed to operate through power loss situations. There is, however a small chance that data file corruption could occur while data is being written to the PC Card. Should a power fluctuation or loss occur at precisely the same time as a write occurs, the data file size information could be corrupted. In most cases only the last few samples of actual data may be lost. To correct this problem, simply insert the PC Card into the Windows 95/98 computer and run the SCANDISK utility (found in Start -> Programs -> Accessories -> System Tools). This utility will likely indicate some file size errors. Allowing windows to fix the errors will most times fix the corrupted files.

If the previous steps do not fix the problem, the user may attempt to FORMAT the flash disk from Windows. This is accomplished by selecting the 8MB disk from the My Computer explorer window and then selecting the FORMAT command from the FILE menu. **IMPORTANT: Ensure the disk selected for formatting is the 8MB flash disk, not any other disk in the system – if the incorrect drive is selected, the computers primary hard drive could be deleted.**

2. I insert the PC Card into the GCS Display and get a message that says: "Invalid Card" or "Disk Error":

The GCS PC Card slot is designed and programmed following the PC Card ATA standard and as a result should be compatible with all ATA style PC Card's. Incompatibilities may, however, still exist with some manufacturer's cards. We are actively testing PC Cards from several manufacturers for compatibility and reliability. If the PC Card in use is shows these types of errors, there may be a compatibility error. Please report the Manufacturer, Type, Part Number and Size to Centrilift Control Technologies for investigation.

Alternately, the PC Card in question could be damaged or require re-formatting. See the answer above for steps to try reformatting the card.

b. Problems using the PC Card with a Windows PC.

1. When I insert my PC Card Flash Disk into the PC Card slot, no new drive appears in the My Computer explorer window, why not?

Many new computer systems have almost all of the Interrupt Request Lines (IRQ's) used with various hardware such as sound cards, CD –Rom drives, Serial ports Parallel ports, USB ports etc. When the PC Card ATA Flash disk is inserted, it requires a free IRQ to perform data transfers to the computers processor. There are only a limited number of IRQ's available in a computer system, and if they are all used when the PC Card is inserted, windows will not be able to add the new drive to the system. On many laptops with multiple PC Cards, this can be alleviated by removing any other PC Cards which are plugged in, such as modems or LAN adapters. Consult your local Information Services personnel for other ways to free up system IRQ's.

2. When I try to open the "log.csv" file, my spreadsheet software prompts me with a dialog box which indicates that all of the file was not loaded. What does this mean?

Most spreadsheet packages have limits on the maximum number of rows a file can have. When the spreadsheet software opens the CSV log file, this file may contain as many as 250000 rows or more. In this case the spreadsheet software will load as many rows of data from the file as will fit within it's own limitations, and then may present some pop-up dialog indicating that not all of the rows in the file could be loaded. Microsoft Excel 95 has a limit of 16383 rows, and Excel 97 has a limit of 65535 rows.

In cases where the log file has too many rows to be loaded, it is necessary to use a text editor such as Wordpad (part of the Windows 95/98 accessories) to copy only the lines of the text file which are desired for viewing to the spreadsheet program.

3. When I try to open one of the CSV files on the PC Card, I get an error which indicates the file could not be opened because of a "read only" condition.

This error was found to occur in some initial shipments of PC Cards from AVED Memory Products. This cause was an invalid DOS format on the cards resulting in a corrupted fat. The solution is to reformat the PC Card in Windows 95/98 which corrects the file structure and boot record. This is accomplished by selecting the 8MB disk from the My Computer explorer window and then selecting the FORMAT command from the FILE menu. **IMPORTANT: Ensure the disk selected for formatting is the 8MB flash disk, not any**

other disk in the system – if the incorrect drive is selected, the computers primary hard drive could be deleted.

NOTE: Formatting the PC Card will result in the loss of all data that was logged to the card. If there is critical data on the card, it can be retrieved with special disk utilities. Please use the information found below to contact one of our support personnel.

If these steps do not provide a solution, contact the Centrilift Control Technologies Group. Please have the following information ready to facilitate problem resolution:

1. The software versions loaded in the GCS Devices (located in the *System, Scada & Security* menu in the *Software Rev Num* sub-menu.
2. The Manufacturers name and type of PC Card, along with a Part Number and a size.
3. A list of symptoms or error messages displayed on the display.

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GCS ESP MOTOR CONTROLLER
Product P/N 900661

OPERATOR'S MANUAL

BAKER HUGHES Centrilift

Centrilift
VORTEX GCS

How To Use This Manual

This manual provides detailed instructions on maintenance, lubrication, installation, and parts identification. Use the table of contents below to locate required information.

Table of Contents

CAREFULLY FOLLOW THE INSTRUCTIONS IN THIS MANUAL FOR OPTIMUM PERFORMANCE AND TROUBLE FREE SERVICE.

INTRODUCTION

This manual applies to Sizes 1020T thru 1140T and 20T thru 140T10 Falk Steelflex Tapered Grid Couplings. Unless otherwise stated, information for Sizes 1020T thru 1140T applies to Sizes 20T thru 140T respectively, e.g. 1020T = 20T, 1100T = 100T, etc. These couplings are designed to operate in either the horizontal or vertical position without modification. Beginning in year 1994 through 2003, these couplings were being supplied with one set of inch series fasteners and one set of Metric fasteners. Beginning in year 2004 only Metric fasteners are being supplied. Refer to Page 6 for part interchangeability.

The performance and life of the couplings depend largely upon how you install and service them.

CAUTION: *Consult applicable local and national safety codes for proper guarding of rotating members. Observe all safety rules when installing or servicing couplings.*

WARNING: *Lockout starting switch of prime mover and remove all external loads from drive before installing or servicing couplings.*

LUBE FITTINGS

Cover halves have $^1/_8$ NPT lube holes. Use a standard grease gun and lube fitting as instructed on Page 4.

LIMITED END FLOAT

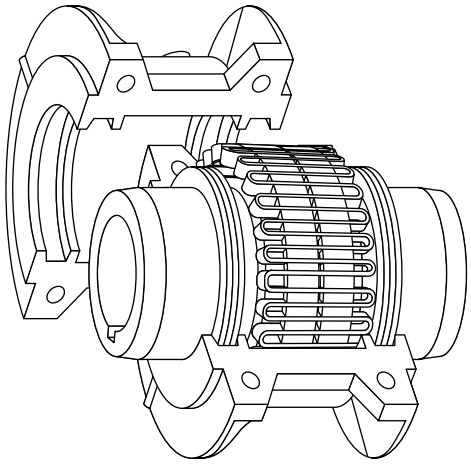
When electric motors, generators, engines, compressors and other machines are fitted with sleeve or straight roller bearings, limited axial end float kits are recommended for protecting the bearings. Falk Steelflex couplings are easily modified to limit end float; refer to Manual 428-820 for instructions.

LUBRICATION

Adequate lubrication is essential for satisfactory operation. Page 2 provides a list of typical lubricants and specifications for general purpose and long term greases. Because of its superior lubricating characteristics and low centrifuge properties, Falk Long Term Grease (LTG) is highly recommended. Sizes 1020T to 1090T10 are furnished with a pre-measured amount of grease for each coupling. The grease can be ordered for larger size couplings.

The use of general purpose grease requires re-lubrication of the coupling at least annually.

TYPE T10 STEELFLEX COUPLING



Long Term Grease (LTG)

The high centrifugal forces encountered in couplings separate the base oil and thickener of general purpose greases. Heavy thickener, which has no lubrication qualities, accumulates in the grid-groove area of Steelflex couplings resulting in premature hub or grid failure unless periodic lubrication cycles are maintained.

Falk Long Term Grease (LTG) was developed specifically for couplings. It resists separation of the oil and thickener. The consistency of Falk LTG changes with operating conditions. As manufactured it is an NLGI #1/2 grade. Working of the lubricant under actual service conditions causes it to become semifluid while the grease near the seals will set to a heavier grade, helping to prevent leakage.

LTG is highly resistant to separation, easily out performing all other lubricants tested. The resistance to separation allows the lubricant to be used for relatively long periods of time.

Steelflex couplings initially lubricated with LTG will not require re-lubrication until the connected equipment is stopped for servicing. If a coupling leaks grease, is exposed to extreme temperatures, excessive moisture, or experiences frequent reversals, more frequent lubrication may be required.

Although LTG grease is compatible with most other coupling greases, the mixing of greases may dilute the benefits of LTG.

USDA Approval

LTG has the United States Department of Agriculture Food Safety & Inspection Service approval for applications where there is no possibility of contact with edible products. (H-2 ratings).

CAUTION: *Do not use LTG in bearings.*

Specifications — Falk LTG

The values shown are typical and slight variations are permissible.

AMBIENT TEMPERATURE RANGE — -20°F (-29°C) to 250°F (121°C). Min. Pump = 20° F (-7° C).

MINIMUM BASE OIL VISCOSITY — 3300SSU (715cST) @ 100°F (38°C).

THICKENER — Lithium & soap/polymer.

CENTRIFUGE SEPARATION CHARACTERISTICS — ASTM #D4425 (Centrifuge Test) — K36 = 2/24 max., very high resistance to centrifuging.

NLGI GRADE (ASTM D-217) — $^1/_2$

CONSISTENCY (ASTM D-217) — 60 stroke worked penetration value in the range of 315 to 360 measured at 77°F (25°C)

MINIMUM DROPPING POINT — 350°F (177°C) minimum

MINIMUM TIMKEN O.K. LOAD — 40 lbs.

ADDITIVES — Rust and oxidation inhibitors that do not corrode steel or swell or deteriorate synthetic seals.

Packaging

14 oz. (0,4 kg) CARTRIDGES — Individual or case lots of 10 or 30.

35 lb. (16 kg)PAIL, 120 lb. (54 kg) KEG & 400 lb. (181 kg) DRUMS.

General Purpose Grease

Annual Lubrication — The following specifications and lubricants for general purpose grease apply to Falk Steelflex couplings that are lubricated annually and operate within ambient temperatures of 0°F to 150°F (-18°C to 66°C). For temperatures beyond this range (see Table 1), consult the Factory.

If a coupling leaks grease, is exposed to extreme temperatures, excessive moisture or experiences frequent reversals, more frequent lubrication may be required.

Specifications — General Purpose Coupling Lubricants

The values shown are typical and slight variations are permissible.

DROPPING POINT — 300°F (149°C) or higher.

CONSISTENCY — NLGI No. 2 with 60 stroke worked penetration value in the range of 250 to 300.

SEPARATION AND RESISTANCE — Low oil separation rate and high resistance to separation from centrifuging.

LIQUID CONSTITUENT — Possess good lubricating properties equivalent to a high quality, well refined petroleum oil.

INACTIVE — Must not corrode steel or cause swelling or deterioration of synthetic seals.

CLEAN — Free from foreign inclusions.

General Purpose Greases Meeting Falk Specifications

Lubricants listed below are typical products only and should not be construed as exclusive recommendations.

TABLE 1 — General Purpose Greases H

Ambient Temperature Range	0°F to 150°F (-18°C to 66°C)	-30°F to 100°F (-34°C to 38°C)
Manufacturer	**Lubricant †**	**Lubricant †**
Amoco Oil Co.	Amolith Grease #2	Amolith Grease #2
BP Oil Co.	Energrease LS-EP2	Energrease LS-EP1
Chevron U.S.A. Inc.	Dura-Lith EP2	Dura-Lith EP1
Citgo Petroleum Corp.	Premium Lithium Grease EP2	Premium Lithium Grease EP1
Conoco Inc.	EP Conolith Grease #2	EP Conolith Grease #2
Exxon Company, USA	Unirex EP2	Unirex EP2
E.F. Houghton & Co.	Cosmolube 2	Cosmolube 1
Imperial Oil Ltd.	Unirex EP2	Unirex EP2
Kendall Refining Co.	Lithium Grease L421	Lithium Grease L421
Keystone Div. (Pennwalt)	81 EP-2	81 EP-1
Lyondell Petrochemical (ARCO)	Litholine H EP 2 Grease	Litholine H EP 2 Grease
Mobil Oil Corp.	Mobilux EP111	Mobilith AW1
Petro-Canada Products	Multipurpose EP2	Multipurpose EP1
Phillips 66 Co.	Philube Blue EP	Philube Blue EP
Shell Oil Co.	Alvania Grease 2	Alvania Grease 2
Shell Canada Ltd.	Alvania Grease 2	Alvania Grease 2
Sun Oil Co.	Ultra Prestige 2EP	Ultra Prestige 2EP
Texaco Lubricants	Starplex HD2	Multifak EP2
Unocal 76 (East & West)	Unoba EP2	Unoba EP2
Valvoline Oil Co.	Multilube Lithium EP Grease	. . .

★ Grease application or re-lubrication should be done at temperatures above 20°F (-7°C). If grease must be applied below 20°F (-7°C), consult The Falk Corporation.

† Lubricants listed may not be suitable for use in the food processing industry; check with lube manufacturer for approved lubricants.

INSTALLATION OF TYPE T10 STEELFLEX TAPERED GRID COUPLINGS

Installation

Only standard mechanics tools, wrenches, a straight edge and feeler gauges are required to install Falk Steelflex couplings. Coupling Sizes 1020T thru 1090T are generally furnished for CLEARANCE FIT with setscrew over the keyway. Sizes 1100T and larger are furnished for an INTERFERENCE FIT without a setscrew.

CLEARANCE FIT HUBS — Clean all parts using a non-flammable solvent. Check hubs, shafts and keyways for burrs. Do not heat clearance fit hubs. Install keys, mount hubs with flange face flush with shaft ends or as otherwise specified and tighten setscrews.

INTERFERENCE FIT HUBS — Furnished without setscrews. Heat hubs to a maximum of 275°F (135°C) using an oven, torch, induction heater or an oil bath. To prevent seal damage, DO NOT heat hubs beyond a maximum temperature of 400°F (205°C).

When an oxy-acetylene or blow torch is used, use an excess acetylene mixture. Mark hubs near the center of their length in several places on hub body with a temperature sensitive crayon, 275°F (135°C) melt temperature. Direct flame towards hub bore using constant motion to avoid overheating an area.

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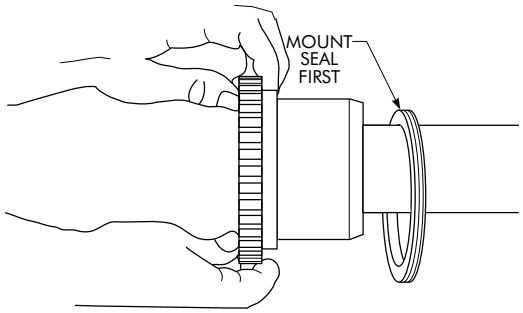
WARNING: If an oil bath is used, the oil must have a flash point of 350°F (177°C) or higher. Do not rest hubs on the bottom of the container. Do not use an open flame in a combustible atmosphere or near combustible materials.

Heat hubs as instructed above. Mount hubs as quickly as possible with hub face flush with shaft end. Allow hubs to cool before proceeding. Insert setscrews (if required) and tighten.

Maximize Performance And Life

The performance and life of couplings depend largely upon how you install and maintain them. Before installing couplings, make certain that foundations of equipment to be connected meet manufacturers' requirements. Check for soft foot. The use of stainless steel shims is recommended. Measuring misalignment and positioning equipment within alignment tolerances is simplified with an alignment computer. These calculations can also be done graphically or mathematically.

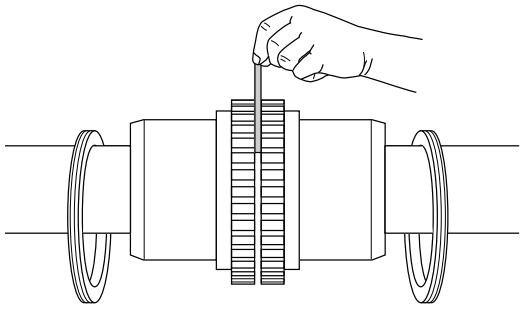
Alignment is shown using spacer bar and straight edge. This practice has proven to be adequate for many industrial applications. However, for superior final alignment, the use of dial indicators (see Manual 458-834 for instructions), lasers, alignment computers or graphical analysis is recommended.



1— Mount Seals And Hubs

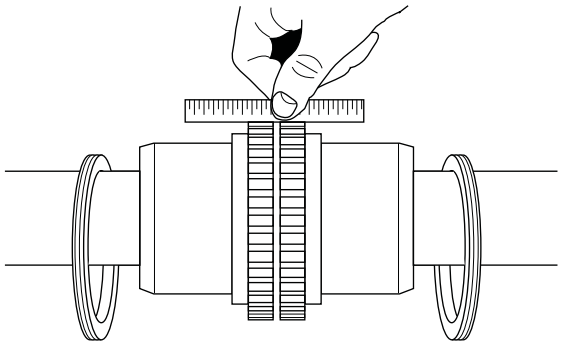
Lock out starting switch of prime mover. Clean all metal parts using a non-flammable solvent. Lightly coat seals with grease and place on shafts BEFORE mounting hubs. Heat interference fit hubs as previously instructed. Seal keyways to prevent leakage. Mount hubs on their respective shafts so the hub face is flush with the end of its shaft unless otherwise indicated. Tighten setscrews when furnished.

2 — Gap and Angular Alignment



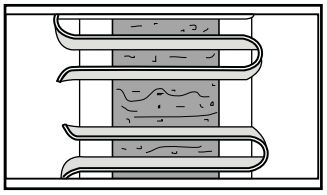
Use a spacer bar equal in thickness to the gap specified in Table 2, Page 5. Insert bar as shown below left, to same depth at 90° intervals and measure clearance between bar and hub face with feelers. The difference in minimum and maximum measurements must not exceed the ANGULAR installation limits specified in Table 2.

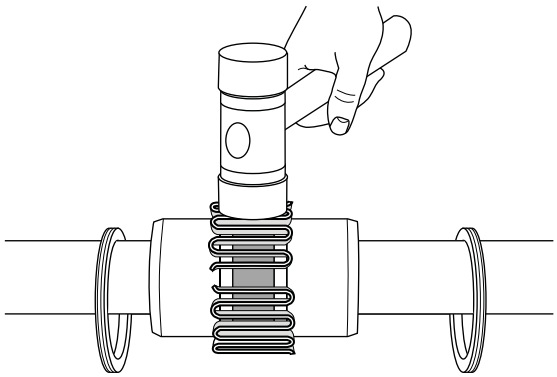
3 — Offset Alignment



Align so that a straight edge rests squarely (or within the limits specified in Table 2) on both hubs as shown above and also at 90° intervals. Check with feelers. The clearance must not exceed the PARALLEL OFFSET installation limits specified in Table 2. Tighten all foundation bolts and repeat Steps 2 and 3. Realign coupling if necessary.

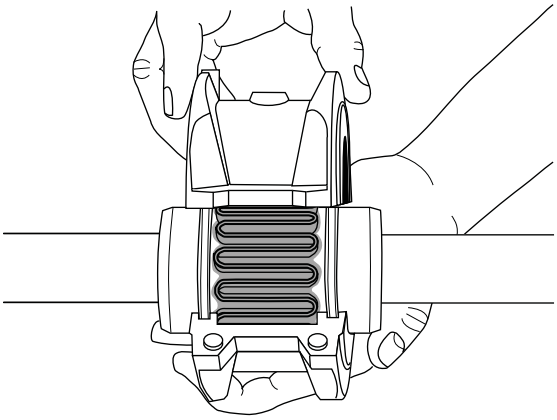
4 — Insert Grid

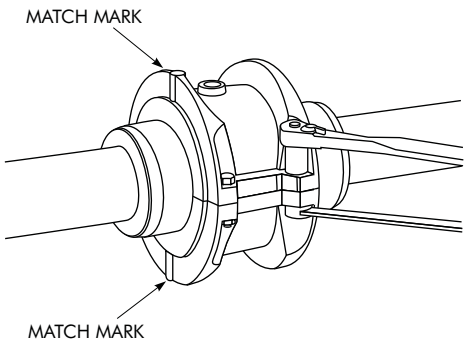




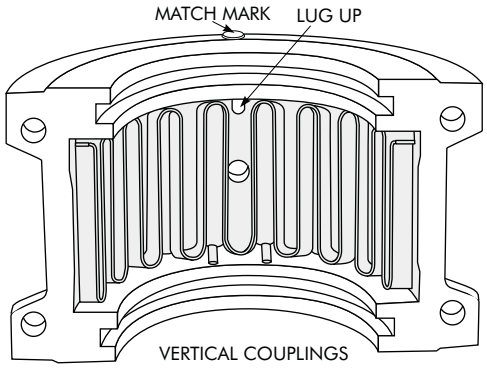
Pack gap and grooves with specified lubricant before inserting grid. When grids are furnished in two or more segments, install them so that all cut ends extend in the same direction (as detailed in the exploded view picture above); this will assure correct grid contact with non-rotating pin in cover halves. Spread the grid slightly to pass over the coupling teeth and seat with a soft mallet.

5 — Pack With Grease And Assemble Covers





Pack the spaces between and around the grid with as much lubricant as possible and wipe off excess flush with top of grid. Position seals on hubs to line up with grooves in cover. Position gaskets on flange of lower cover half and assemble covers so that the match marks are on the same side (see above). If shafts are not level (horizontal) or coupling is to be used vertically, assemble cover halves with the lug and match



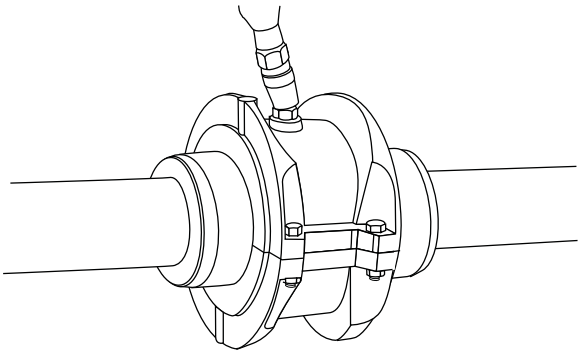
mark UP or on the high side. Push gaskets in until they stop against the seals and secure cover halves with fasteners, tighten to torque specified in Table 2. Make sure gaskets stay in position during tightening of fasteners. ***CAUTION:*** *Make certain lube plugs are installed before operating.*

ANNUAL MAINTENANCE

For extreme or unusual operating conditions, check coupling more frequently.

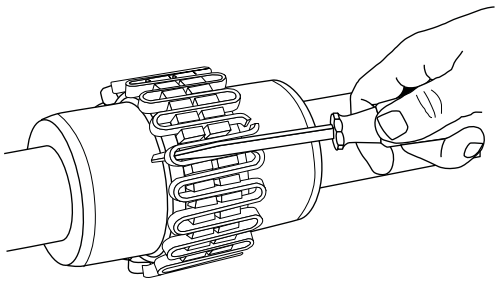
1. Check alignment per steps on Page 3. If the maximum operating misalignment limits are exceeded, realign the coupling to the recommended installation limits. See Table 2 for installation and operating alignment limits.
2. Check tightening torques of all fasteners.
3. Inspect seal ring and gasket to determine if replacement is required. If leaking grease, replace.
4. When connected equipment is serviced, disassemble the coupling and inspect for wear. Replace worn parts. Clean grease from coupling and repack with new grease. Install coupling using new gasket as instructed in this manual.

Periodic Lubrication



The required frequency of lubrication is directly related to the type of lubricant chosen, and the operating conditions. Steelflex couplings lubricated with common industrial lubricants, such as those shown in Table 1, should be relubed annually. The use of Falk Long Term Grease (LTG) will allow relube intervals to be extended to beyond five years. When relubing, remove both lube plugs and insert lube fitting. Fill with recommended lubricant until an excess appears at the opposite hole. ***CAUTION:*** Make certain all plugs have been inserted after lubricating.

Coupling Disassembly And Grid Removal



Whenever it is necessary to disconnect the coupling, remove the cover halves and grid. A round rod or screwdriver that will conveniently fit into the open loop ends of the grid is required. Begin at the open end of the grid section and insert the rod or screwdriver into the loop ends. Use the teeth adjacent to each loop as a fulcrum and pry the grid out radially in even, gradual stages, proceeding alternately from side to side.

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TYPE T COUPLING INSTALLATION & ALIGNMENT DATA

Maximum life and minimum maintenance for the coupling and connected machinery will result if couplings are accurately aligned. Coupling life expectancy between initial alignment and maximum operating limits is a function of load, speed and lubrication. Maximum operating values listed in Table 2 are based on cataloged allowable rpm.

Values listed are based upon the use of the gaps listed, standard coupling components, standard assemblies and cataloged allowable speeds.

Values may be combined for an installation or operating condition.

Example: 1060T max. operating misalignment is .016" parallel plus .018" angular.

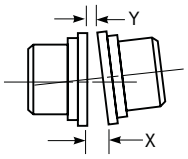
NOTE: For applications requiring greater misalignment, refer application details to Falk.

Angular misalignment is dimension X minus Y as illustrated below.

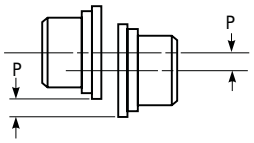
Parallel misalignment is distance P between the hub center lines as illustrated below.

End float (with zero angular and parallel misalignment) is the axial movement of the hubs(s) within the cover(s) measured from "O" gap.

ANGULAR MISALIGNMENT



PARALLEL OFFSET MISALIGNMENT



END FLOAT

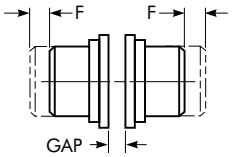


TABLE 2 — Misalignment & End Float

SIZE	Installation Limits						Operating Limits						Cover Fastener Tightening Torque Values Inch or Metric Series Fasteners		Allow Speed (rpm)	Lube Wt	
	Parallel Offset-P		Angular (x-y)		Hub Gap 10%		Parallel Offset-P		Angular (x-y)		End Float Physical Limit (Min) 2 x F						
	Max Inch	Max mm	Max Inch	Max mm	Inch	mm	Max Inch	Max mm	Max Inch	Max mm	Inch	mm	(lb-in)	(Nm)		lb	kg
1020T	.006	0,15	.003	0,08	.125	3	.012	0,30	.010	0,25	.210	5,33	100	11,3	4500	.06	0,03
1030T	.006	0,15	.003	0,08	.125	3	.012	0,30	.012	0,30	.198	5,03	100	11,3	4500	.09	0,04
1040T	.006	0,15	.003	0,08	.125	3	.012	0,30	.013	0,33	.211	5,36	100	11,3	4500	.12	0,05
1050T	.008	0,20	.004	0,10	.125	3	.016	0,41	.016	0,41	.212	5,38	200	22,6	4500	.15	0,07
1060T	.008	0,20	.005	0,13	.125	3	.016	0,41	.018	0,46	.258	6,55	200	22,6	4350	.19	0,09
1070T	.008	0,20	.005	0,13	.125	3	.016	0,41	.020	0,51	.259	6,58	200	22,6	4125	.25	0,11
1080T	.008	0,20	.006	0,15	.125	3	.016	0,41	.024	0,61	.288	7,32	200	22,6	3600	.38	0,17
1090T	.008	0,20	.007	0,18	.125	3	.016	0,41	.028	0,71	.286	7,26	200	22,6	3600	.56	0,25
1100T	.010	0,25	.008	0,20	.188	5	.020	0,51	.033	0,84	.429	10,90	312	35	2440	.94	0,43
1110T	.010	0,25	.009	0,23	.188	5	.020	0,51	.036	0,91	.429	10,90	312	35	2250	1.1	0,51
1120T	.011	0,28	.010	0,25	.250	6	.022	0,56	.040	1,02	.556	14,12	650	73	2025	1.6	0,74
1130T	.011	0,28	.012	0,30	.250	6	.022	0,56	.047	1,19	.551	14,00	650	73	1800	2.0	0,91
1140T	.011	0,28	.013	0,33	.250	6	.022	0,56	.053	1,35	.571	14,50	650	73	1650	2.5	1,14

TABLE 3 — Coupling Cover Fastener Identification

SIZE	Inch Series Fasteners				METRIC FASTENERS	
	Old Style		New Style			
1020-1070T10		SAE Grade 8 ★		SAE Grade 8		Property Class 10.9
1080-1090T10		SAE Grade 8		SAE Grade 8		Property Class 10.9
1100-1140T10		SAE Grade 5		SAE Grade 5		Property Class 8.8

★ Older style covers, Sizes 1020T10 thru 1070T10 must utilize socket head cap screws and locknuts held by the cover.

PARTS IDENTIFICATION

All coupling parts have identifying part numbers as shown below. Parts 3 and 4 (Hubs and Grids), are the same for both Type T10 and T20 couplings. All other coupling parts are unique to Type T10. When ordering parts, always SPECIFY SIZE and TYPE shown on the COVER.

PARTS INTERCHANGEABILITY

Parts are interchangeable between Sizes 20T and 1020T, 30T and 1030T, etc. except as noted.

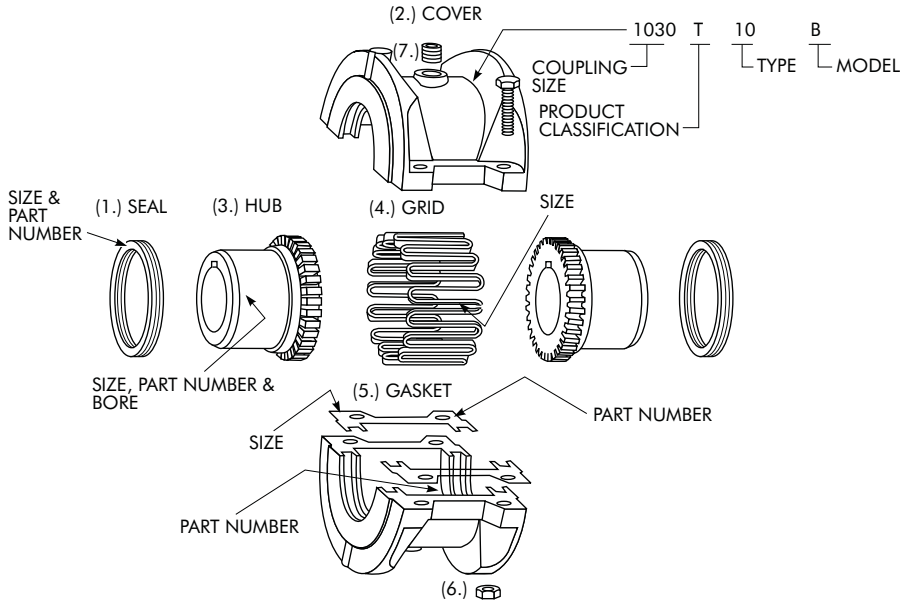
GRIDS — Size 1020T thru 1140T Steelflex couplings use blue or non-painted grids. Older models, 20T thru 140T, use orange grids.

CAUTION: Blue or non-painted grids may be used in all applications, but DO NOT substitute orange grids for blue or nonpainted.

*COVERS — **CAUTION:** DO NOT mix cover halves of different designs. Sizes 1020T thru 1070T10 covers have been manufactured in several different two-rib designs and 80T thru 140T covers have been manufactured with two and three ribs.*

HARDWARE — Older style covers, Sizes 1020T10 thru 1070T10, utilized socket head cap screws with captured locknuts. The new style covers use hex head cap screws (either inch or metric from year 1994 through 2003 and only Metric beginning in 2004). Specify the style cover when ordering replacement parts.

PART NUMBER LOCATION



PART DESCRIPTION

1. Seal (T10)
2. Cover (T10)
3. Hub (Specify bore and keyway)
4. Grid
5. Gasket (T10)
6. Metric Fasteners (T10).
7. Lube Plug

ORDER INFORMATION

1. Identify part(s) required by name above.
2. Furnish the following information.

   EXAMPLE:
   Coupling Size: 1030
   Coupling Type: T10
   Model: B
   Bore: 1.375
   Keyway: .375 x .187
3. Contact your Falk Distributor or Falk for price and availability.

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00-02-0161
Revised 04-08
Section 05

Installation for 4-1/2 in. (114 mm) dial Pressure Murphygage® and Swichgage® instruments

Model Series: OPLC, OPLG, OPLBP, 45APE, 45APEBP, PT167EX and 45 Series
Options: -OS, -ES, -P4 and -P6

Please read the following instructions before installing. A visual inspection is recommended before mounting. General Information and these installation instructions are intended for all 4-1/2 in. (114 mm) dial pressure models.

GENERAL INFORMATION

WARNING

BEFORE BEGINNING INSTALLATION OF THIS MURPHY PRODUCT

- **Disconnect all electrical power to the machine.**
- **Make sure the machine cannot operate during installation.**
- **Follow all safety warnings of the machine manufacturer.**
- **Read and follow all installation instructions.**

OPLC and OPLFC Swichgage instruments have high and low limit contacts to monitor, alarm or shut down. The OPLC has a flanged case. A method to override the low limit contact for start-up is provided on most models. See Operation Test section–page 3. OPLFC can be direct or panel mounted (see page 2).

OPLG and OPLFG Murphygage indication-only pressure instrument are similar to OPLC and OPLFC models, without switch (limit) contacts.

45 Series includes a magnetic switch to stop an engine or electric motor each time the gage contact operates. A lockout push button overrides low contact for startup. Other variations available.

45APE and 45APEF Series are versions of the OPLC Series featuring 2 snap-acting SPDT switches instead of the pointer type contacts. These units do not include low contact lockout.

OPLBP and 45APEBP are versions of the OPLC and 45APE featuring pilot duty limit switches connected to an internal latching control relay for "on/off" control directly or through a motor starter.

PT167EX The Murphy PT167EX is a pressure Swichgage instrument connected to a threaded pressure diaphragm housing. The Swichgage instrument is enclosed in an explosion-proof case and is CSA rated for Class I, Division 1, Groups C and D.

Specifications

Dial: White on black, dual scale, psi/kPa standard, 4-1/2 in. (114 mm) diameter.
Case: Die cast aluminum, surface or panel mount.
Process Connection: 1/4 NPTM thru 1000 psi; 1/2 NPTM 1500 - 10,000 psi.

Precautions: Do NOT exceed rated pressure range.
Dope or use teflon tape on connection threads. Do not block the inlet orifice. For direct mount into the process, a vertical or ninety degree mounting is recommended.

Use wrench on shank to tighten or loosen connection. Do not twist case when installing, this will damage internal components and will void the warranty. **Do not overtighten.**

Use shock mounts as necessary to prevent excessive vibration.

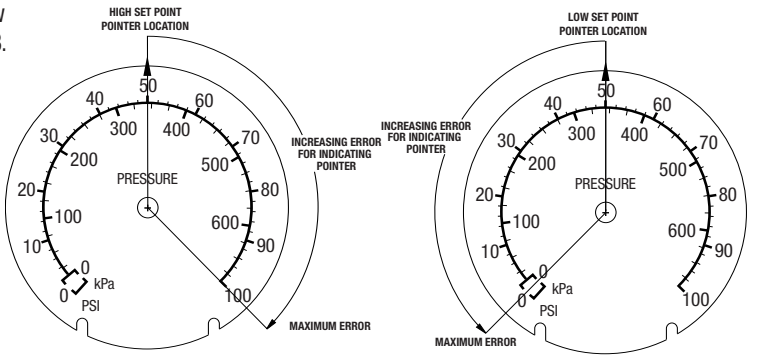
If liquid in the system freezes, it will expand and will damage the tube.

For 45APE Series – Low setpoint should be limited to the lower 1/2 scale and upper setpoint should be limited to the upper 1/2 scale.

Sensing Element: Bronze or 316 stainless steel bourdon tube.
Gage Accuracy:
All models and 45APE/45APEF between switch points:
±2% for first and last quarters of scale; middle half of scale is ±1%.
Model 45APE/45APEF
Indicating Pointer above or below set point:

Range	Accuracy (±% F.S.) above and below s.p. only
<100 (except 15 psi)	10
15	15
100-300	4
400-1500	2
2000	12
3000-5000	8

Based on testing performed with switch point at mid scale which represents worst case.



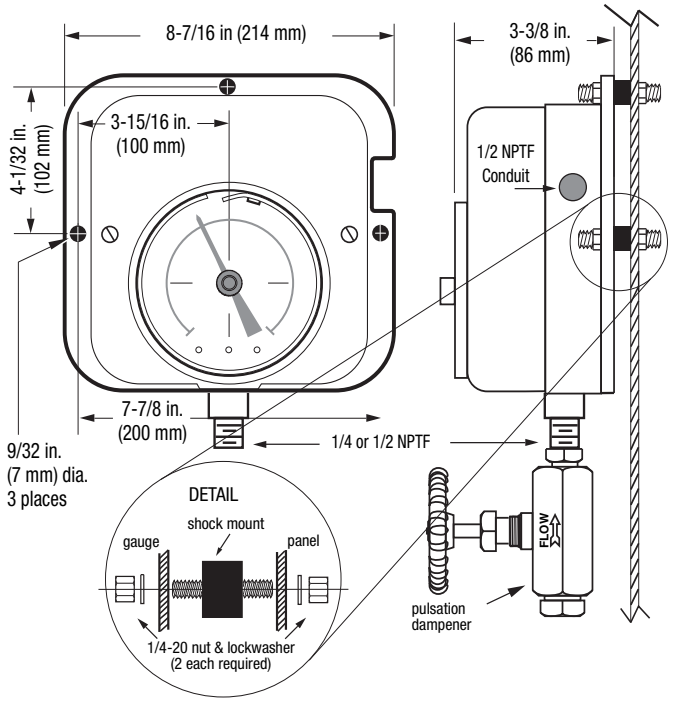
Switch Point Accuracy: ±1.5% (45APE/45APEF).
Switch Reset Deadband: Approximately 10% FS (45APE/45APEF).
Snap-Acting Switches: See wiring information (page 4) (45APE/45APEF).
Overrange: Do not exceed 10% FS above full range.
Pressure Relief Disc: Back of case (except EX models).
Dry Relay Contact ("BP" Models): 10 A @ 28 VDC or 10 A @ 120 VAC.
Wire Connections (Surface Mount): *1/2 NPTF conduit/ terminal block.*
Wire Connections (Panel Mount): *Wire leads, 18 AWG (1.0 mm²) x 9 in. (229 mm) long.*
Wire Connections (-ES, -OS): *1/2 NPTM conduit and wire leads,*
All except 45APEF:
18 AWG (1.0 mm²) x 33 in. (838 mm) long.
45APEF
24 AWG (0.22 mm²) x 33 in. (838 mm) long.
Item Weight: 5 lbs 6 oz (2.4 kg) approximately.
Explosion-proof models: 21 lb. (9.5 kg) approx.
Item Dimensions: 10 x 9 x 6 in. (254 x 229 x 152 mm) approximately.
Explosion-proof models: *12 x 12 x 9 in. (305 x 305 x 229 mm) approximately.*

Warranty

A limited warranty on materials and workmanship is given with this FW Murphy product. A copy of the warranty may be viewed or printed by going to www.fwmurphy.com/support/warranty.htm.
*Selected configurations are third party listed. Consult factory for details.

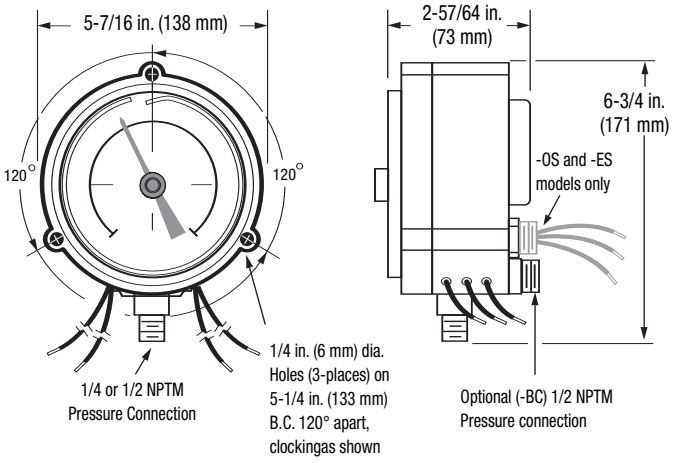
OPL Series Wall Mount

Flanged case design intended for wall mount, it can also be direct mounted. Shown with shock mounts and pulsation dampener.

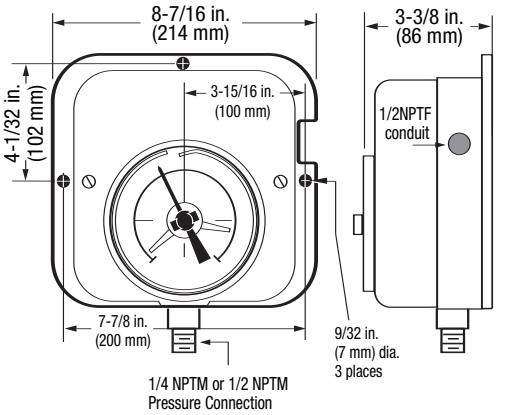


OPL Series Flush Mount

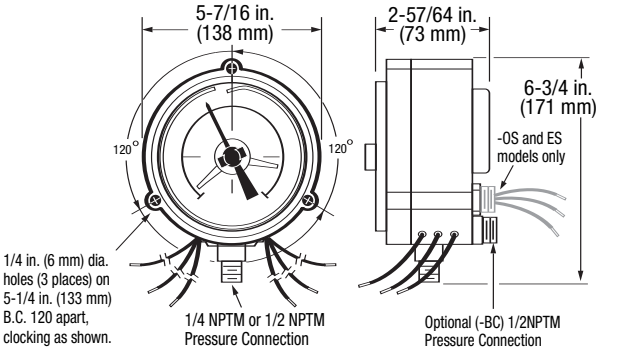
Round case design to be mounted in a panel from 1/32 in. (1 mm) to 1/8 in. (3 mm) thick. It can also be direct mounted. Shown with pulsation dampener.



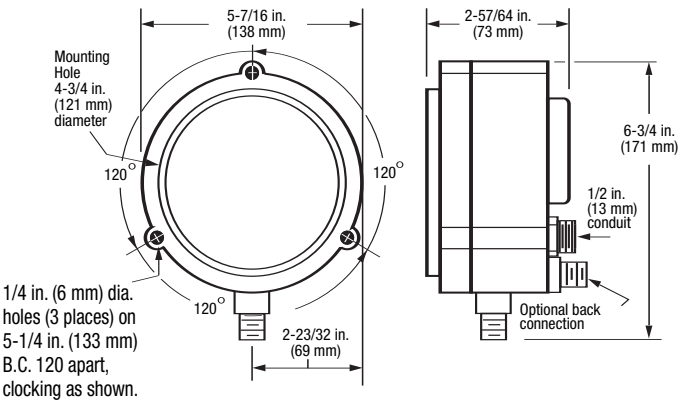
45PE Series Wall Mount



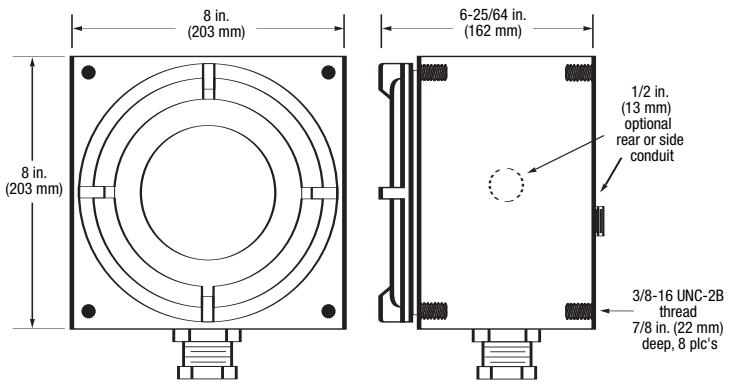
45PE Series Flush Mount



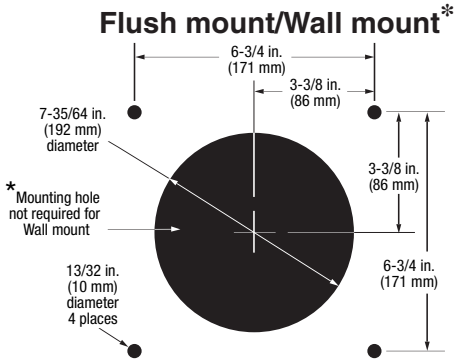
Options "OS" and "ES" Flush Mount Case



Explosion-proof Case Mount Explosion-proof case can be mounted from face or rear.



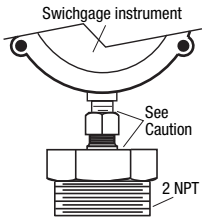
Flush mount/Wall mount*



OPTIONS

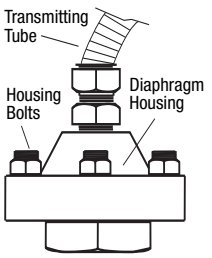
-OS and -ES (oil sealed and environment sealed case) for corrosive environment, feature a panel mount case or screw directly into the process. See Case Mounting (p-2).

-P6 Sealed mechanism with a typical application for oil well lead lines. Its 2 NPT housing and diaphragm seal filled with silicon fluid attaches directly into a 2 NPT tee on the lead line. Tighten only the 2-5/8 in. (67 mm) hex fitting.



CAUTION: Do not tamper with or break sealed connections.

-PL4 Stainless steel armored capillary and remote seal mechanism protects the gage from highly viscous and/or corrosive fluids.



1. Loosen the eight housing bolts until the bottom housing is free to turn.

CAUTION: Do Not unscrew the green diaphragm capsule.

2. Tighten the bottom housing to the pressure source.
3. Evenly tighten (by staggering the tightening) the eight housing bolts to 25±3 foot lbs.
4. Route capillary away from heat source such as exhaust manifold. Carefully coil and secure excess capillary to avoid damage.

CAUTION: Do Not cut capillary or make sharp bends.

ADJUSTMENTS

OPL/45 Series Limit Contact Adjustments

Facing the dial, left side knob is the "Low limit" contact and the "High limit" contact is located to the right. To set the limit contacts simply turn the fingertip type knob to the desired point on the scale.

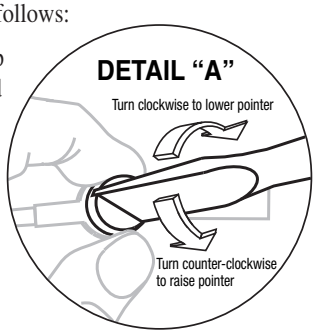
45APE Series Trip Point Adjustments

The 45APE Series features a stacked limit indicator adjustments knob. The bottom half knob adjusts the "Low" limit indicator, the top half is to adjust the "High" limit indicator. To set the limit contacts simply turn the fingertip type knob to the desired point on the scale.

OPL and 45 Series Indicating Point Adjustments

To reset to zero or to a known value do as follows:

1. Turn off electrical power. Remove the snap ring and very carefully remove the lens and contact assembly (or open hinged cover).
2. Hold the pointer hub with thumb and forefinger then turn screw to desired point. See **DETAIL "A".**
3. Replace lens and contact assembly and snap ring (or close hinged cover), and turn on the power.

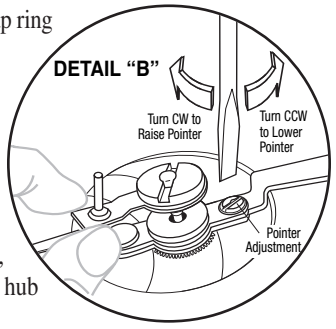


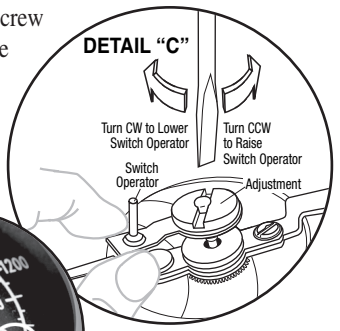
45APE Series Pointer Adjustments (if necessary)

Verify that pointer is at zero with zero pressure.

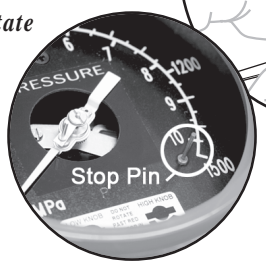
To reset to zero or to a known value proceed as follows:

1. Turn off electrical power. Remove the snap ring and very carefully remove the lens and contact assembly (or open hinged cover).
2. Hold the the Switch Operator and the pointer hub with thumb and forefinger, then turn the Pointer Adjustment screw to the desired point. See **DETAIL "B".**
3. If the Switch Operator needs adjustment, hold the Switch Operator and the pointer hub with thumb and forefingers as show on **DETAIL "C",** and turn the adjustment screw until the Switch Operator aligns with the indicating pointer.
4. Replace the lens and contact assembly and the snap ring (or close hinged cover). Turn the power back on.





CAUTION: Don't rotate set point arms past stop pins in circle.



OPERATION TEST INSTRUCTIONS

OPLC, OPLFC and OPLBP

1. Perform operation test after the unit is installed and wired appropriately. (See the typical wiring diagram, on page 4.)
2. When pressure is applied to the instrument, the pointer will travel in a clockwise direction. Adjust the limit contacts to the desired settings.
3. To start, place the toggle switch in the "start" position or otherwise override low contact.
4. After the indication pointer rises above the low limit contact, return the toggle switch or override device to the "run" position.
5. To test the limit contacts, turn the limit contact to be tested until it touches the pointer. That will trip the control circuit.
6. Reset the shutdown or alarm circuit device and repeat above sequence for each contact/trip point.

45 Series

1. Repeat steps 1 and 2. (See OPLC operation test instructions.)
2. Press the semi-automatic pushbutton located on the low contact knob.
3. Reset the magnetic switch pushbutton.
4. After the indication pointer rises above the low limit contact, the lockout - pushbutton automatically disengages and the low limit is armed.
5. Repeat steps 5 and 6. (See OPLC operation test instructions.)

45APE, 45PEF and 45APEBP

1. Repeat steps 1 and 2. (See OPLC operation test instructions.)
2. To test the switches, turn the trip point indicator until it is aligned with the Swichgage pointer. This is the approximate trip point. Continue to rotate until the snap switch operates.
3. Reset the shutdown or alarm circuit device.

TYPICAL ELECTRICAL DIAGRAMS

WARNING: PERFORM THE WIRING OPERATION WITH THE POWER SOURCE "OFF". MAKE SURE THE VOLTAGE AND CURRENT REQUIREMENTS ARE WITHIN THE SWICHGAGE RATINGS. BEFORE WIRING DETERMINE VOLTAGE AND POLARITY FOR THE APPLICATION. USE THE APPROPRIATE WIRE SIZE. ALL CONNECTIONS SHOULD BE MADE USING A SPADE (FORKED) OR RING TERMINALS. FOR PIGTAIL CONNECTIONS USE WIRE NUTS. CONDUIT IS RECOMMENDED TO PROTECT WIRES FROM DAMAGE.

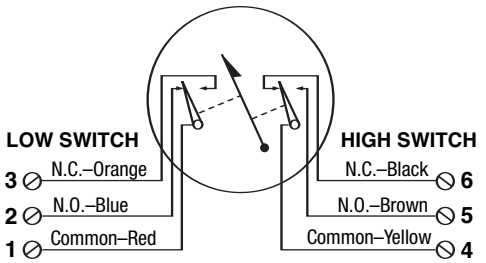
OPLC and OPLFC

Contact Rating: 1 SPDT, Center Off; 2 A, 30 VDC, 1 A, 125 VAC pilot duty.

NOTE: Swichgage pointer shown at rest (shelf) position.

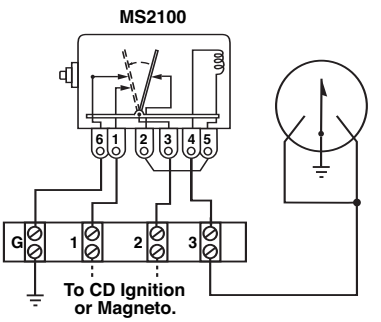
45APE and 45APEF

Contact Rating: 2-SPDT snap-switches (one for high and low pressure), 2 A inductive, 250 VAC each switch. ***NOTE:*** *Swichgage pointer shown at rest (shelf) position.* Low setpoint should be limited to the lower 1/2 scale and upper setpoint should be limited to the upper 1/2 scale.



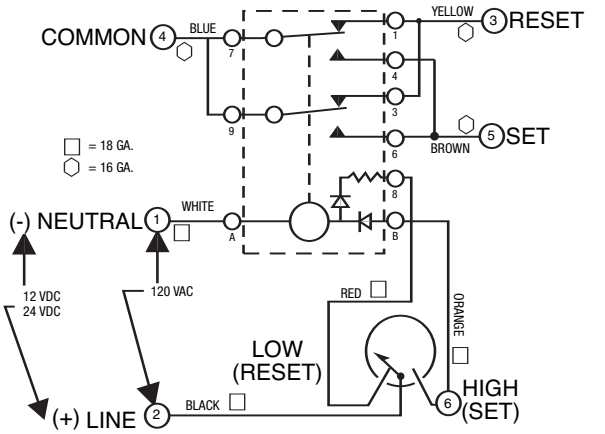
45 Series with MS2100

Models available for Battery ignition, CD ignition, Magneto or 110VAC systems. **Contact Rating:** 12/32 VDC coil, 10 A, 32 VDC battery ignition contacts; Magneto ignition coil, 10 A magneto ignitions contacts; CD ignition coil, 10 A CD ignition contacts; 120 VAC coil, 10 A, 120 VAC contacts.
NOTE: *Swichgage pointer shown in the operating position.*



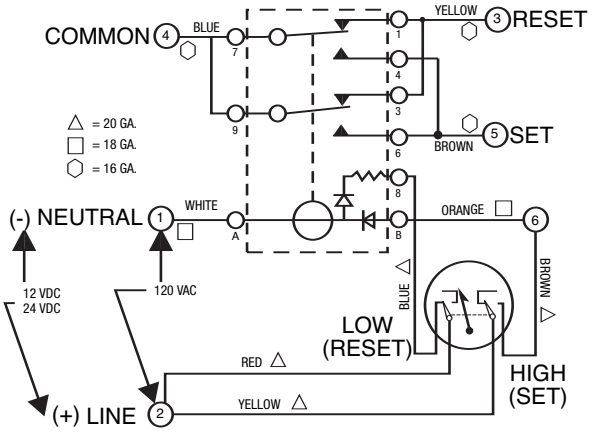
OPLBP

Contact Rating: SPDT dry relay contacts; 10 A, 125 VAC.
NOTE: Swichgage pointer shown at rest (shelf) position.



45APEBP

Contact Rating: SPDT dry relay contacts; 10 A, 125 VAC.
NOTE: Swichgage pointer shown at rest (shelf) position.



Transformer relay Assembly

For higher voltages, Murphy TR Assemblies can be used in conjunction with any Swichgage instrument.

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Section 20
(00-02-0185)

Shock/Vibration Control Switches Installation Instructions

Models: VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94

Please read the following instructions before installing. A visual inspection of this product for damage during shipping is recommended before mounting. It is your responsibility to have a qualified person install the unit, and make sure installation conforms with NEC and local codes.

GENERAL INFORMATION

WARNING

BEFORE BEGINNING INSTALLATION OF THIS MURPHY PRODUCT

- ✔ Disconnect all electrical power to the machine.
- ✔ Make sure the machine cannot operate during installation.
- ✔ Follow all safety warnings of the machine manufacturer.
- ✔ Read and follow all installation instructions.

LISTED*

Model VS2EX

Description

The Murphy shock and vibration switches are available in a variety of models for applications on machinery or equipment where excessive vibration or shock can damage the equipment or otherwise poses a threat to safe operation. A set of contacts is held in a latched position through a mechanical latch and magnet mechanism. As the level of vibration or shock increases an inertia mass exerts force against the latch arm and forces it away from the magnetic latch causing the latch arm to operate the contacts. Sensitivity is obtained by adjusting the amount of the air gap between the magnet and the latch arm plate.

Applications include all types of rotating or reciprocating machinery such as cooling fans, engines, pumps, compressors, pump jacks, etc.

Models

VS2: Base mount; non hazardous locations.

VS2C: C-clamp mount; non hazardous locations.

VS2EX: Explosion-proof; Class I, Div. 1, Groups C and D.

VS2EXR: Explosion-proof with remote reset.

VS2EXRB: Explosion-proof; Class I, Div. 1, Group B; with remote reset.

VS94: Base mount; non hazardous locations, NEMA 4X/IP66.

Remote Reset Feature (VS2EXR, VS2EXRB and VS94 only)

Includes built-in electric solenoid which allows reset of tripped unit from a remote location. Standard on VS2EXR and VS2EXRB. Optional on VS94 (options listed below).

-R15: Remote reset for 115 VAC

-R24: Remote reset for 24 VDC

Time Delay Option (VS94 only)

Overrides trip operation on start-up. For VS94 series models, the delay time is field-adjustable from 5 seconds up to 6-1/2 minutes with a 20-turn potentiometer (15 seconds per turn approximately). Options listed below:

-T15: Time delay for 115 VAC

-T24: Time delay for 24 VDC

Space Heater Options (VS94 only)

This optional space heater board prevents moisture from condensing inside the VS94 Series case. Options listed below:

-H15: Space heater for 115 VAC

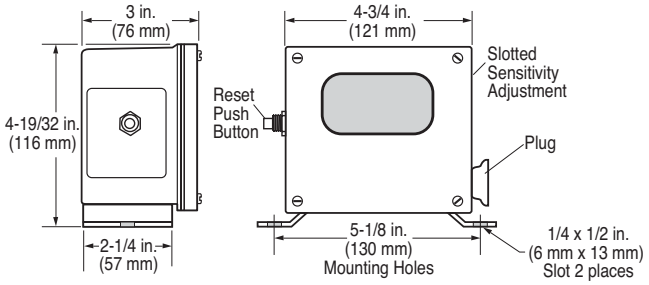
-H24: Space heater for 24 VDC

Warranty

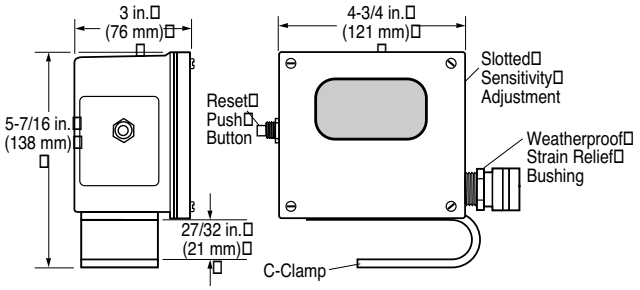
A limited warranty on materials and workmanship is given with this FW Murphy product. A copy of the warranty may be viewed or printed by going to www.fwmurphy.com/support/warranty.htm

DIMENSIONS

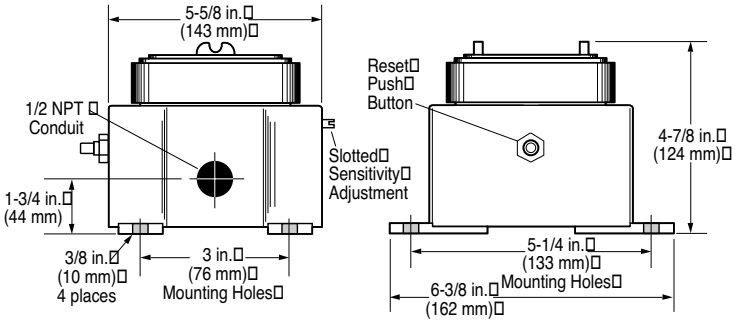
VS2



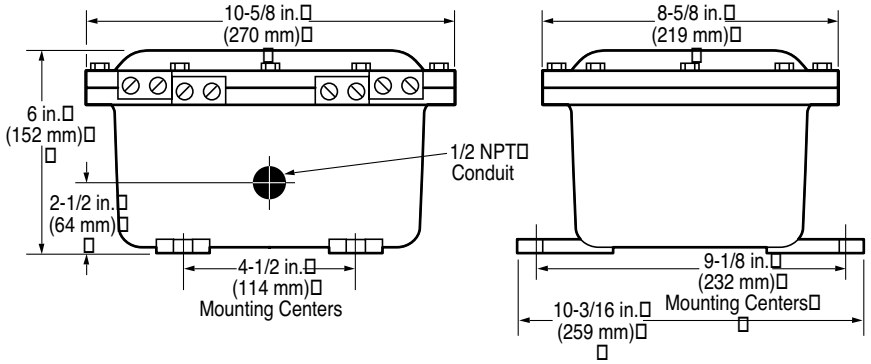
VS2C



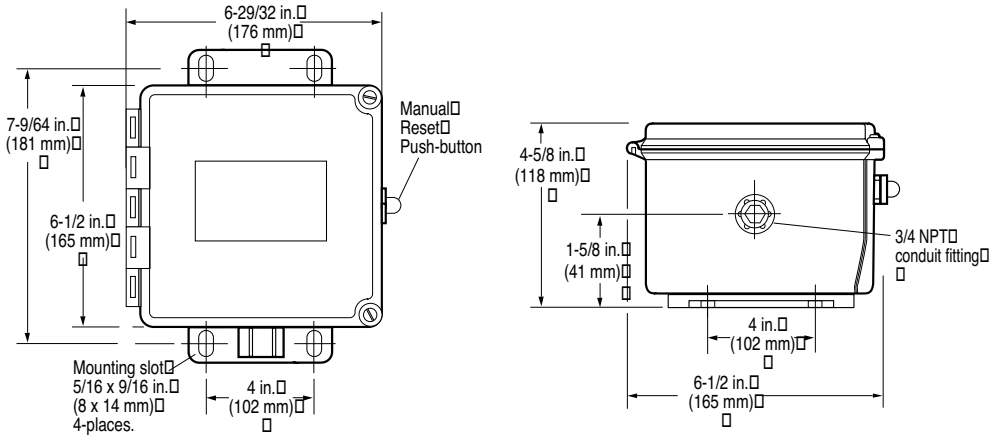
VS2EX and VS2EXR



VS2EXRB



VS94



SPECIFICATIONS

VS2 and VS2C

- **Case:** Weatherproof (equal to NEMA 3R) suitable for non-hazardous areas.
  VS2: *Base mount*
  VS2C: *C-clamp mount. Includes 45 feet (13.7 meters), 2-conductor 16 AWG, 30 strands/0.25 mm strand dia. (1.5 mm²) cable, and five cable hold down clamps.*
- **Contacts:** SPDT double make leaf contacts, 5A @ 480 VAC.
- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.

VS2EX

- **Case:** Explosion-proof and weatherproof aluminum alloy housing; meets NEMA 7/IP50 specifications; Class I, Division 1, Groups C & D; UL and CSA listed*
  VS2EX: *base mount.*
- **Snap-switches:** 2-SPDT snap-switches; 5A @ 480 VAC;* 2A resistive, 1A inductive, up to 30 VDC.
- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.
- **Normal Operating Temperature:** -40 to 140°F (-40 to 60°C).

VS2EXR

- **Case:** Same as VS2EX.
- **Snap-switch:** 1-SPDT snap-switch and reset coil; 5A @ 480 VAC;* 2A resistive, 1A inductive, up to 30 VDC.
- **Remote Reset (optional):**

Option	*Operating Current*
-R15:	*350 mA @ 115 VAC*
-R24:	*350 mA @ 24 VDC*

- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.
- **Normal Operating Temperature:** -40 to 140°F (-40 to 60°C).

VS2EXRB

- **Case:** Explosion-proof aluminum alloy housing; rated Class I, Division 1, Group B hazardous areas.
- **Snap-switch:** 1-SPDT snap-switch with reset coil (option available for additional SPDT switch); 5A @ 480 VAC; 2A resistive, 1A inductive, up to 30 VDC.
- **Remote Reset:**

Option	*Operating Current*
-R15:	*350 mA @ 115 VAC*
-R24:	*350 mA @ 24 VDC*

- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.

VS94

- **Case:** Polyester fiberglass reinforced; NEMA type 4 and 4X; IP66; CSA types 4 and 12.
- **Conduit Fitting:** 3/4 NPT conduit fitting connection.
- **Normal Operating Ambient Temperature:** 0 to 140°F (-18 to 60°C).
- **Snap-switches:** 2-SPDT snap acting switches; 5A @ 480 VAC; 2A resistive, 1A inductive, up to 30 VDC.
- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.
- **Heater (optional):**

Option	*Operating Current*
H15	*.023 A @ 115 VAC*
H24	*.12 A @ 24 VDC*

- **Remote Reset (optional):**

Option	*Operating Current*
R15	*.17 A @ 115 VAC*
R24	*.36 A @ 24 VDC*

- **Time Delay (optional):**

Option	*Operating Current*	*Standby Current*
T15	*.360 A @ 115 VAC*	*.01 A @ 115 VAC*
T24	*1.15 A @ 24 VDC*	*.01 A @ 24 VDC*

- **Time Delay/Remote Reset:** Adjustable 20-turn potentiometer from 5 seconds to 6-1/2 minutes (15 seconds per turn approximately).

*CSA and UL listed with 480 VAC rating.

INSTALLATION

WARNING: STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING INSTALLATION.

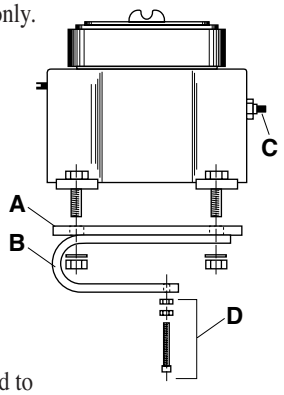
The VS2 and VS94 series shock switches are sensitive to shock and vibration in all three planes of motion - up/down, front/back and side/side. Front/back is the most sensitive (The reset pushbutton is located on the "front" of the unit). For maximum sensitivity mount the unit so that the front faces into the direction of rotation of the machine. (See Dimensions on page 2 for sensitivity adjustment location).

The VS2 and VS94 Series must be firmly attached/mounted to the machine so that all mounting surfaces are in rigid contact with the mounting surface of the machine. For best results, mount the instrument in-line with the direction of rotating shafts and/or near bearings. In other words, the reset push button should be mounted pointing into the direction of shaft rotation (see page 5). It may be necessary to provide a mounting plate or bracket to attach the VS2 and VS94 Series to the machine. The mounting bracket should be thick enough to prevent induced acceleration/vibration upon the VS2 or VS94 Series. Typically 1/2 in. (13mm) thick plate is sufficient. See illustrations on page 5 for typical mounting locations.

CAUTION: A dust boot is provided on the reset pushbutton for all series to prevent moisture or dust intrusion. The sensitivity adjustment for model VS2EX is not sealed; therefore, mounting orientation should be on a horizontal plane or with the sensitivity adjustment pointing down. Sensitivity adjustment for model VS2 is covered by a plug. The plug must be in place and tight to prevent moisture or dust intrusion.

C-Clamp Installation (VS2C model only)

A C-Clamp is supplied with the VS2C model only. The C-Clamp is shipped installed on the VS2C but must be installed on the VS2EX and VS2EXR switches.



1. The C-Clamp **(B)** will already be installed on a 1/4 in. (6 mm) thick steel mounting plate **(A)**. Bolt the VS2 switch to the mounting plate as illustrated — with four 5/16 in. bolts, nuts, and washers.
2. The mounting location should provide convenient access to the TATTLETALE® push button **(C)**.
3. The hardened set screw and nuts **(D)** are used to tighten the switch to an I-Beam or cross member such as a Sampson post of an oilwell pumpjack.

Continued on next page.

All Models

WARNING: STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING INSTALLATION.

1. Firmly secure the unit to the equipment using the base foot mount or C-Clamp if applicable. See ***C-Clamp Installation*** page 3.

For oilwell pumpjacks attach the VS2 and VS94 Series to the Sampson post or walking beam. See ***Typical Mounting Locations*** page 5.

2. Make the necessary electrical connections to the vibration switch. See ***Internal Switches,*** page 6 for electrical terminal locations and page 7 for typical wiring diagrams. **DO NOT EXCEED VOLTAGE OR CURRENT RATINGS OF THE CONTACTS.** Follow appropriate electrical codes/methods when making electrical connections. Be sure that the run of electrical cable is secured to the machine and is well insulated from electrical shorting. Use of conduit is recommended.

NOTE: If the electrical cable crosses a pivot point such as at the pivot of the walking beam, be sure to allow enough slack in the cable so that no stress is placed on the cable when the beam moves.

If conduit is not used for the entire length of wiring, conduit should be used from the electrical supply box to a height above ground level that prevents damage to the exposed cable from the elements, rodents, etc. or as otherwise required by applicable electrical codes. If conduit is not attached directly to the VS2 and VS94 Series switch, use a strain relief bushing and a weatherproof cap on the exposed end of the conduit. A "drip loop" should be provided in the cable to prevent moisture from draining down the cable into the conduit should the weathercap fail.

Sensitivity Adjustment

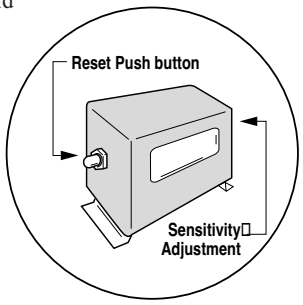
WARNING: REMOVE ALL POWER BEFORE OPENING THE ENCLOSURE. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON PERFORM ADJUSTMENTS, AND MAKE SURE IT CONFORMS WITH NEC AND LOCAL CODES. DO NOT ADJUST SENSITIVITY WHILE THE MACHINE IS RUNNING. STAND CLEAR OF THE MACHINE AT ALL TIMES WHEN IT IS OPERATING.

All models of the VS2 and VS94 Series cover a wide range of sensitivity. Each model is adjusted to the specific piece of machinery on which it is installed. After the switch has been installed in a satisfactory location (see page 5) the sensitivity adjustment will be increased or decreased so that the switch does not trip during start-up or under normal operating conditions. This is typically done as follows:

1. REPLACE ALL COVERS, LIDS, AND ELECTRICAL ENCLOSURES.

2. Press the reset push button to engage the magnetic latch. To be sure the magnetic latch has engaged, observe latch through the window on the VS2 and VS2C (see DETAIL "A"). On the VS2EX, VS94 series the reset button will remain depressed meaning the magnetic latch has engaged.

DETAIL "A"



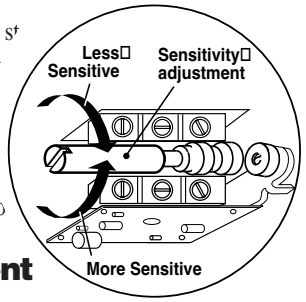
3. Start the machine.

4. If the instrument trips on start-up, allow the machine to stop. Turn the sensitivity adjustment 1/4 turn clockwise, (adjustment for VS94 and VS2EXRB models is located within the box, see DETAIL "B").

WARNING: MAKE THE AREA NON-HAZARDOUS BEFORE OPENING THE EXPLOSION-PROOF (-EX) ENCLOSURES.

Depress the reset button and restart the machine. Repeat this process until the unit does not trip on start-up.

DETAIL "B"



5. If the instrument does NOT trip on start-up, st sensitivity adjustment 1/4 turn counter-cl up/stop process until the instrument trips on adjustment 1/4 turn clockwise (less sensit verify that the instrument will not trip on start

6. Verify that the unit will trip when abnormal sho

VS94 Time Delay Adjustment

1. Apply power to the time delay circuit. (see page 7 for time delay circuit). The time delay function will be initiated.

2. Time the length of the delay with a watch. Let time delay expire. After it expires, the override circuit will de-energize the solenoid, allowing the latch arm to trip. A clicking noise is heard.

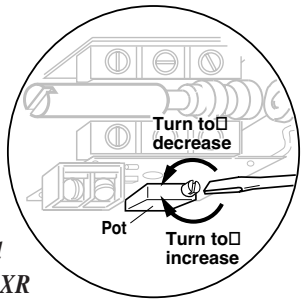
WARNING: REMOVE ALL POWER BEFORE OPENING ACCESS DOOR. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON ADJUST THE UNIT, AND MAKE SURE IT CONFORMS WITH NEC AND LOCAL CODES.

3. TURN THE POWER OFF TO RESET THE TIME DELAY CIRCUIT.

NOTE: Allow 30 seconds bleed-time between turning the power "OFF" and "ON".

4. Locate the time adjustment pot (DETAIL "C"). The time is factory-set at the lowest setting (5 seconds approximately). To increase time, rotate the 20-turn pot clockwise as needed (15 seconds per turn approximately).

DETAIL "C"



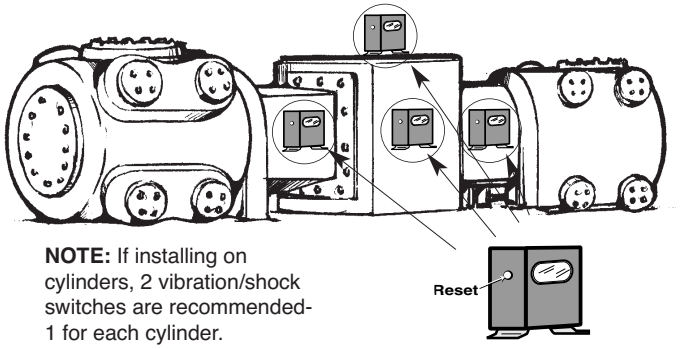
5. Repeat the above steps as necessary to obtain desired time delay.

NOTE: An external time delay can be used with the remote reset feature of the VS2EXR series to provide a remote reset and override of the trip operation on start-up. Time delay must automatically disconnect after equipment start-up.

TYPICAL MOUNTING LOCATIONS

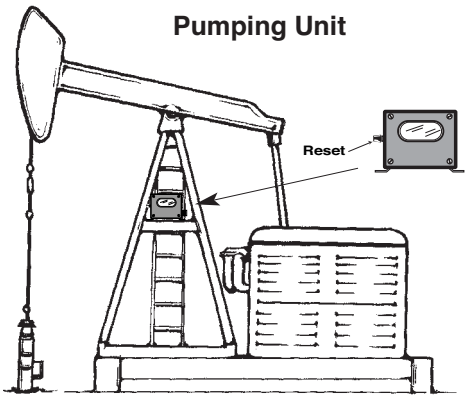
NOTE: These are typical mounting locations for best operation. Other mountings are possible. See *Installation* section on page 3.

2-Throw Balance-Opposed Compressor

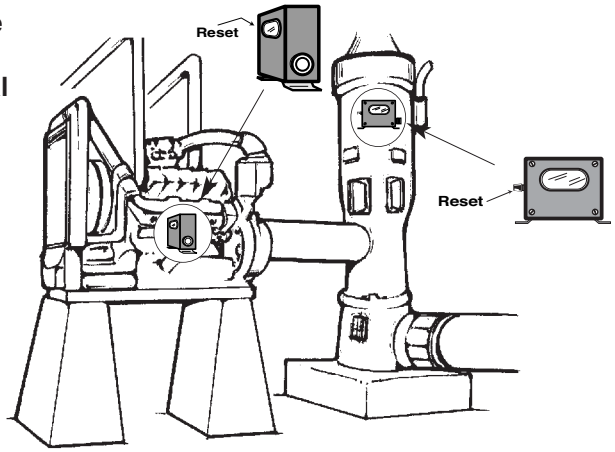


NOTE: If installing on cylinders, 2 vibration/shock switches are recommended- 1 for each cylinder.

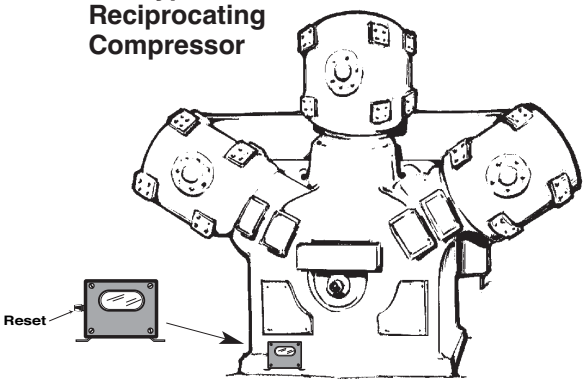
Pumping Unit



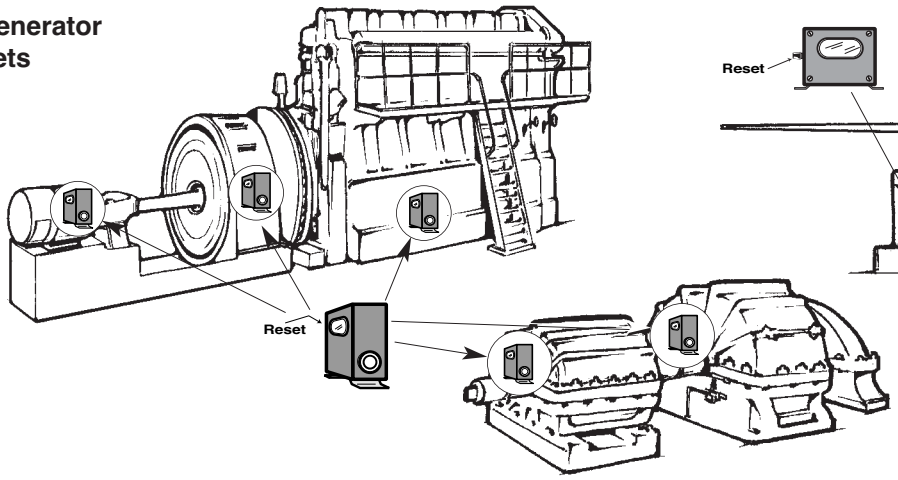
Engine and Vertical Shaft Pump



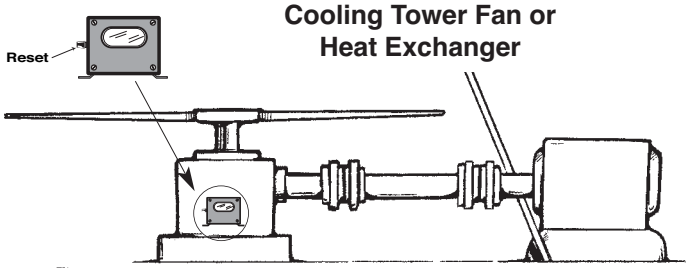
"Y" Type Reciprocating Compressor



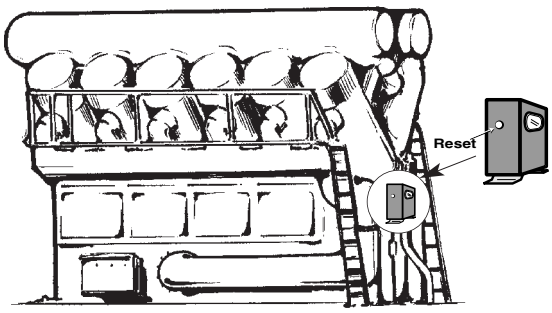
Generator Sets



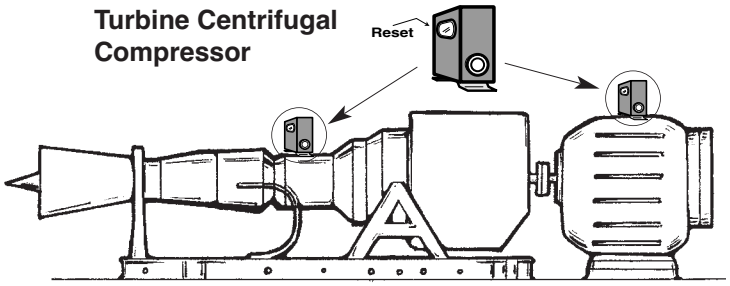
Cooling Tower Fan or Heat Exchanger



Engine Compressor

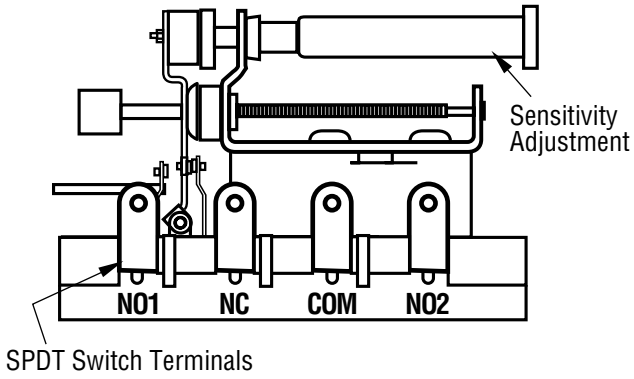


Turbine Centrifugal Compressor

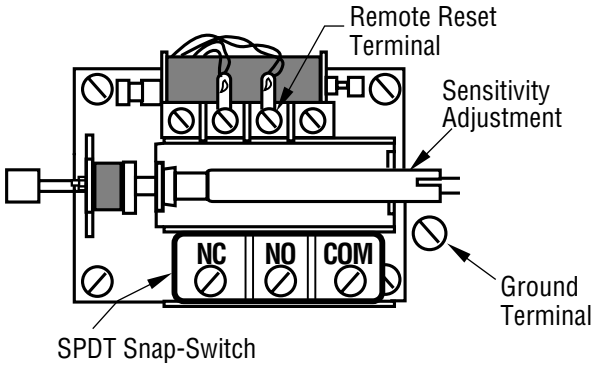


INTERNAL SWITCHES

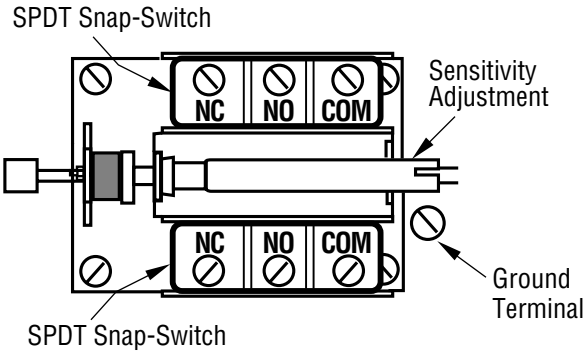
VS2 and VS2C



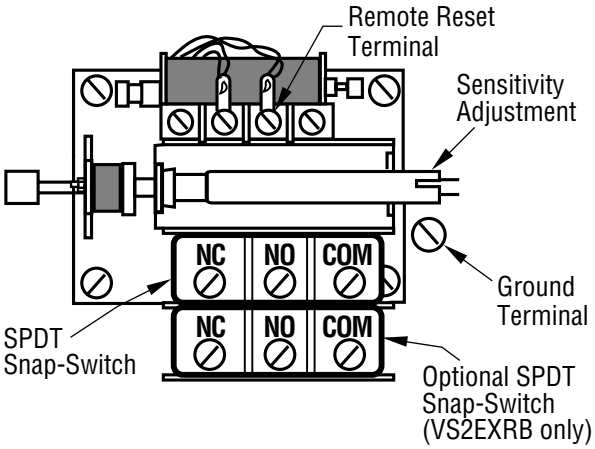
VS2EXR



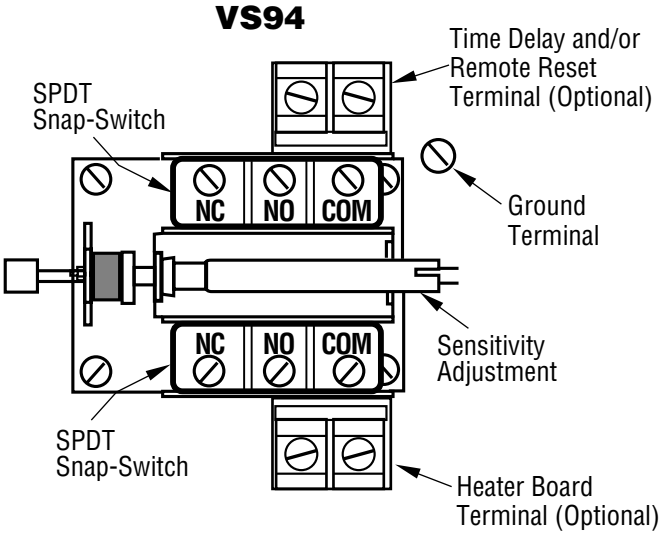
VS2EX



VS2EXB and VS2EXRB

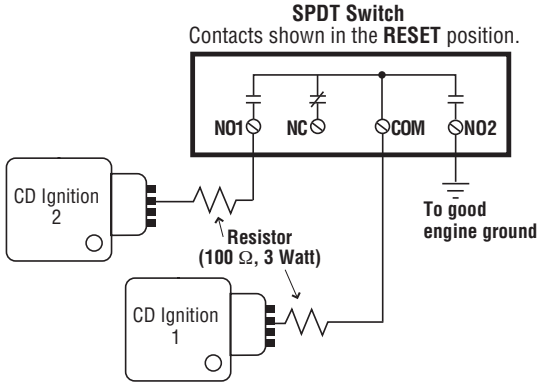


VS94

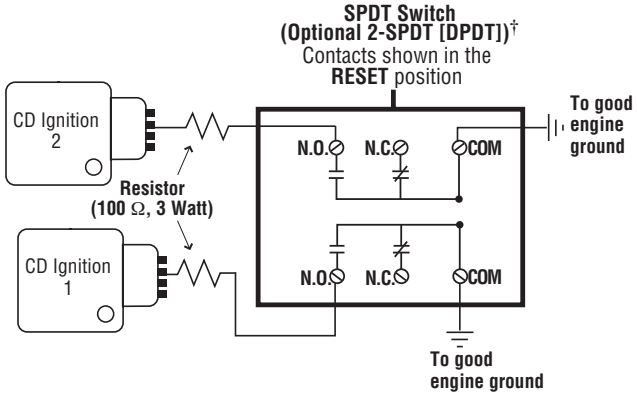


WARNING: REMOVE POWER BEFORE OPENING THE UNIT (ACCESS DOOR). STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING THE WIRING OPERATION. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON INSTALL AND WIRE THE UNIT, AND MAKE SURE IT CONFORMS WITH NEC AND APPLICABLE CODES.

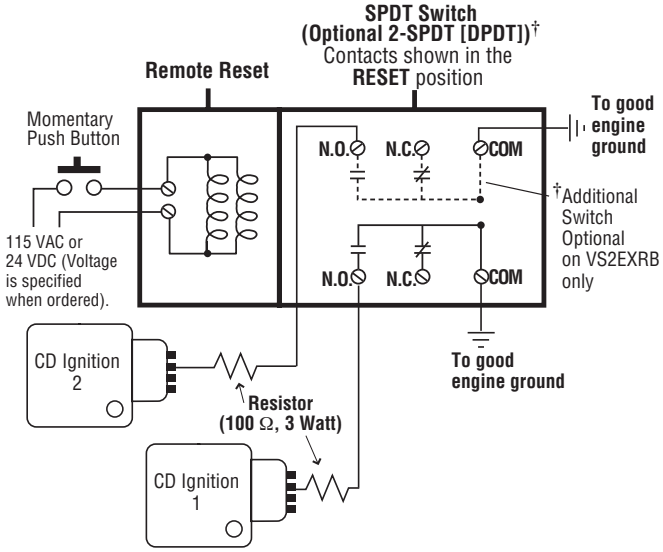
VS2 and VS2C
Typical Wiring Diagram for Single or Dual CD Ignition



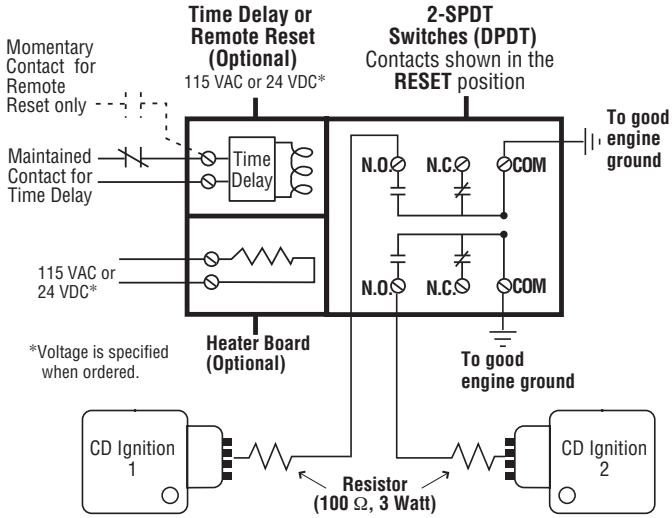
VS2EX
Typical Wiring Diagram for Single or Dual CD Ignitions



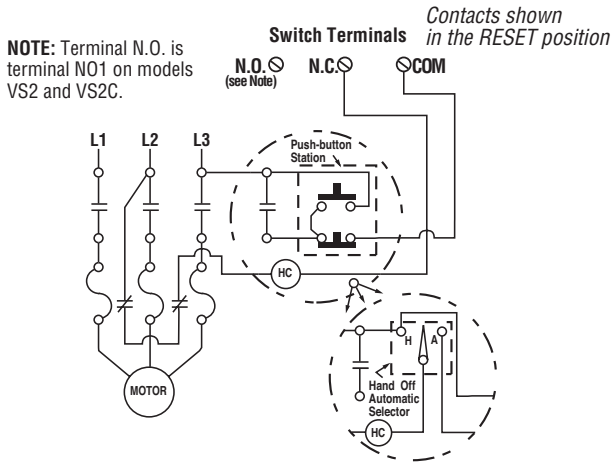
VS2EXR and VS2EXRB
Typical Wiring Diagram for Single or Dual CD Ignitions



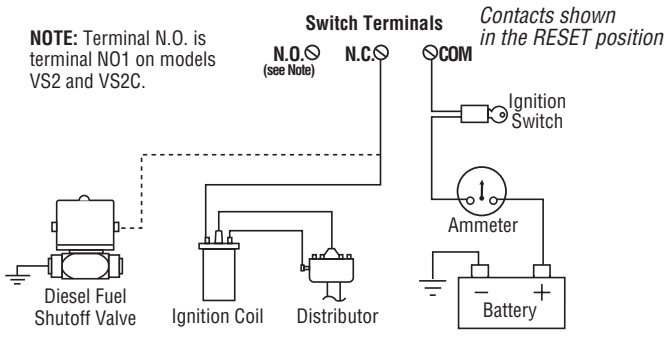
VS94
Typical Wiring Diagram for Single or Dual CD Ignitions



VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94
Typical Wiring Diagram for Electric Motors



VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94
Typical Wiring Diagram for Distributor Ignition or Diesel



SERVICE PARTS

PART NO.	DESCRIPTION
VS2	
20000030	Movement assembly
20000031	Glass and gasket assembly
20000032	Reset push button assembly
VS2C	
20000030	Movement assembly
20000031	Glass and gasket assembly
20000032	Reset push button assembly
20050021	Mounting clamp
20000185	VS2C 5-clamp hardware package assembly.
20050465	2-Conductor electrical cable, 45 feet (13.7 meters)
VS2EX	
20010091	Movement assembly
20050087	Cover
00000309	Cover gasket
20010090	Snap-switch and insulator kit (1 switch per kit) **prior to September 1, 1995.***
20000288	**Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.***
20000289	C-clamp conversion mounting kit
VS2EXR	
20000262	Movement assembly
20050087	Cover
00000309	Cover gasket
20010090	Snap-switch and insulator kit (1 switch per kit) **prior to September 1, 1995.***
20000288	**Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.***
20000049	Reset solenoid assembly (115 VAC)
20000234	Reset solenoid assembly (24 VDC)
20000289	C-clamp conversion mounting kit

PART NO.	DESCRIPTION
VS2EXRB	
20010090	Snap-switch and insulator kit (1 switch per kit) **prior to September 1, 1995.***
20000288	**Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.***
20000057	*Inside* snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D **prior to September 1, 1995.***
20000058	*Outside* snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D **prior to September 1, 1995.***
20000287	***Outside* snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D manufactured on September 1, 1995 or later.***
20000290	***Inside* snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D manufactured on September 1, 1995 or later.***
20050077	Adjustment shaft
20000262	Movement assembly
20000049	Reset solenoid assembly (115 VAC)
20000234	Reset solenoid assembly (24 VDC)
VS94 Series	
25050506	Dust boot
00000232	Conduit fitting
20010090	Snap-switch and insulator kit (1 switch per assembly) **prior to September 1, 1995.****
20000288	**Snap-switch and insulator kit (1 switch per assembly) for models manufactured on September 1, 1995 or later.*****

* If no date code is found, refer to the old switch. Models with date 0895 and before use old switch. Dated 0995 after, use straight snap-switch arm, no rollers.

** Models dated Q1 thru Q8 (formed snap-switch arm and rollers).

***Models date coded Q9 thru Q12 and R1 thru R12 (straight snap-switch arm, no rollers).

MURPHY

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Reservoir Accessories

Filler Breathers, Strainers, Diffusers,
Fluid Level/Temperature Gauges

Non-Metallic Filler Breathers
Single-Hole and Six-Hole Styles

Anti-Splash Design!

Specifications:
Materials:
Body: Non-corrodible glass filled nylon.
Valve: Nylon/Nitrile.
Dipstick: ABS, acetal Hi/Lo indicators.

Filtration Element: Expanded polyurethane foam, 10 micron.

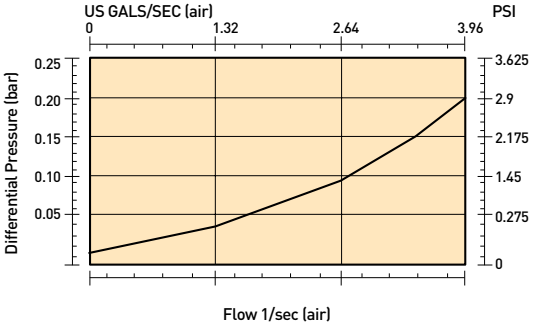
Operating Temperatures: -22°F (-30°C) to 195°F (90°C).

Seals: Nitrile (single-hole), cork gasket (six-hole).

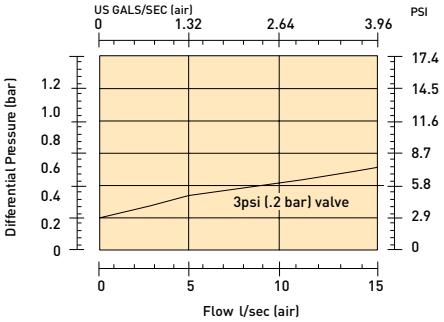
Pressurization Options: 3 psi (0.2 bar).

Dipstick: (optional) 7.9 in. (200 mm) or 15.8 in. (400 mm) lengths with adjustable Hi/Lo indicators.

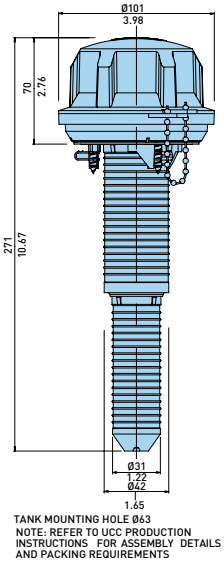
(Non-pressurized)



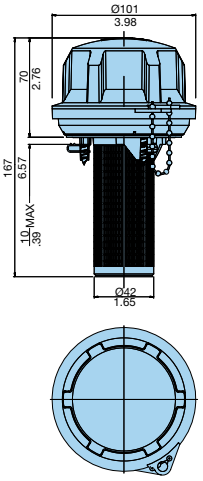
(Pressurized)



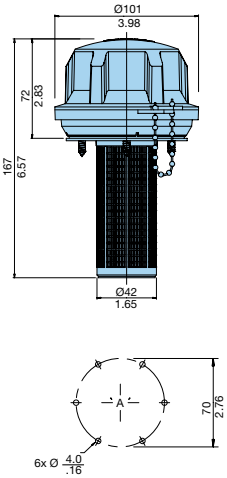
Telescopic Strainer



Single-Hole Option



Six-Hole Option



Linear Measurement= $\frac{mm}{in}$

Non-pressurized

Single-Hole New Part No.	Single-Hole Obs. Part No.	Six-Hole New Part No.	Six-Hole Obs. Part No.	Micron Rating	Description	Screws*
AB.98210001.UC	FB1.A1A1A2P	AB.98810001.UC	FB1.D1A1A2P	10	Filler breather without strainer	(6)-M10x.5
AB.98210011.UC	FB1.A1A1B2P	AB.98810011.UC	FB1.D1A1B2P	10	Filler breather with 3.7" (95 mm) strainer	(6)-M10x.5
AB.98210021.UC	FB1.A1A1C2P	AB.98810021.UC	FB1.D1A1C2P	10	Filler breather with telescopic strainer	(6)-M10x.5

Pressurized

Single-Hole Part No.	Six-Hole New Part No.	Six-Hole Obs. Part No.	Micron Rating	Description	Screws*
Not Available	AB.98812001.UC	FB1.D1B1A2P	10	3 psi (.2 bar) without strainer	(6)-M10x.5
Not Available	AB.98812011.UC	FB1.D1B1B2P	10	3 psi (.2 bar) with 3.7" (95 mm) strainer	(6)-M10x.5
Not Available	AB.98812021.UC	FB1.D1B1C2P	10	3 psi (.2 bar) with telescopic strainer	(6)-M10x.5

Dipsticks

New Part Number	Obsolete Part Number	Description
B.68.206	DIP.FB2	Pack of (10) x 7.9"
DIP.FB4	–	Pack of (10) x 15.8"

*Mounting screws for six-hole only

Parker Hannifin Corporation
Hydraulic Filter Division
Metamora, OH

Non-Metallic Breathers

Threaded Type

Specifications:

Materials:
Body: Nylon 66.
Valve: Nylon/Nitrile.
Dipstick: ABS, acetal Hi/Lo indicators.

Filtration Element: Expanded polyurethane foam, 10 micron.

Operating Temperatures: -22°F (-30°C) to 195°F (90°C).

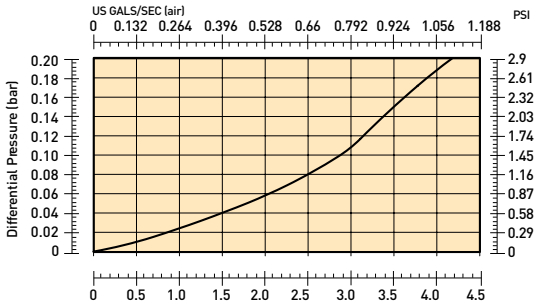
Seals: Nitrile.

Pressurization Options: 3 psi (0.2 bar).

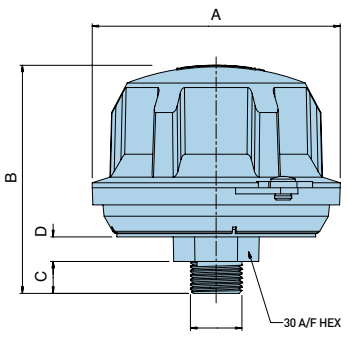
Dipstick: (optional) 7.9 in. (200 mm) or 15.8 in.(400mm) lengths with adjustable Hi/Lo indicators.

Anti-Splash Design!

COMPACT THREADED

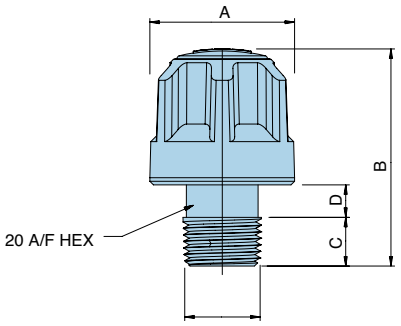


Standard Threaded



Thread size

Compact Threaded



Thread size

Compact Threaded

New Part Number	Obs. Part Number	Micron Rating	Thread	Pressure	"A"	"B"	"C"	"D"
AB.683102.UC*	SB1.A1A2P*	10	1/4"NPT	non-pressurized	1.6" (40 mm)	2.2" (57 mm)	.55" (14 mm)	.24" (6 mm)
AB.68Y102.UC*	SB1.C1A2P*	10	1/2" NPT	non-pressurized	1.6" (40 mm)	2.4" (60 mm)	.53" (13.5 mm)	.35" (9 mm)
AB.68Z102.UC*	SB1.D1A2P*	10	3/4" NPT	non-pressurized	1.6" (40 mm)	2.4" (60 mm)	.55" (14 mm)	.35" (9 mm)

*Pack of (10) pieces.

Standard Threaded

New Part Number	Obs. Part Number	Micron Rating	Thread	Pressure	"A"	"B"	"C"	"D"
Not Available	FB1.C1A3A2P	10	1/2"NPT	non-pressurized	4.0" (101 mm)	3.7" (93 mm)	.51" (13 mm)	.39" (10 mm)
FB1.C1B3A2P	–	10	1/2" NPT	3 psi (.2 bar)	4.0" (101 mm)	3.7" (93 mm)	.51" (13 mm)	.39" (10 mm)
AB.98410201.UC	FB1.B1A3A2P	10	3/4" NPT	non-pressurized	4.0" (101 mm)	3.8" (95 mm)	.63" (16 mm)	.39" (10 mm)
AB.98412201.UC	FB1.B1B3A2P	10	3/4" NPT	3 psi (.2 bar)	4.0" (101 mm)	3.8" (95 mm)	.63" (16 mm)	.39" (10 mm)

Dipsticks

New Part Number	Obs. Part Number	Description
B.68.206	DIP.FB2	Pack of (10) x 7.9"
DIP.FB4	–	Pack of (10) x 15.8"

Parker Hannifin Corporation
Hydraulic Filter Division
Metamora, OH

Metal Filler Breathers

Flange Type

Specifications:

Materials:
Cap & Plate: Nickel chrome plated steel.
Valve: Nylon/Nitrile.

Gasket: Cork.

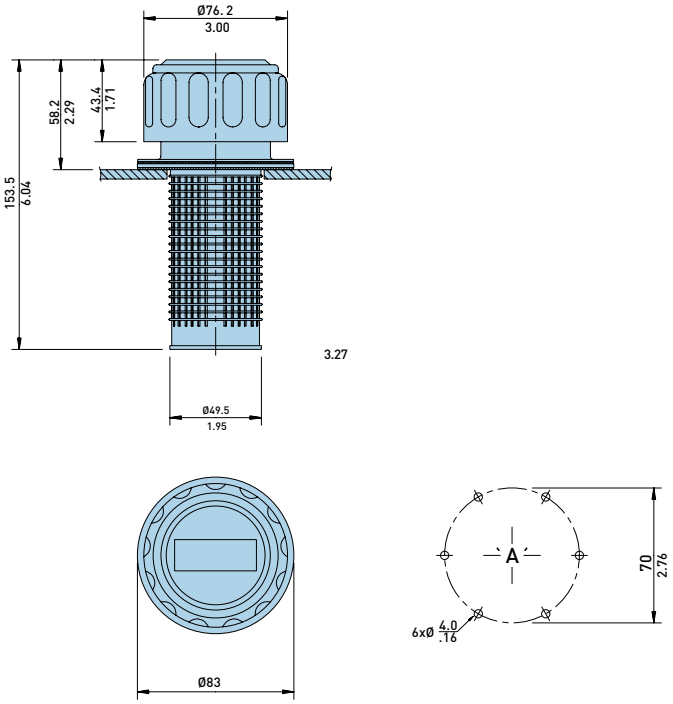
Filtration Element: Expanded polyurethane foam, 10 micron.

Operating Temperatures: -22°F (-30°C) to 195°F (90°C).

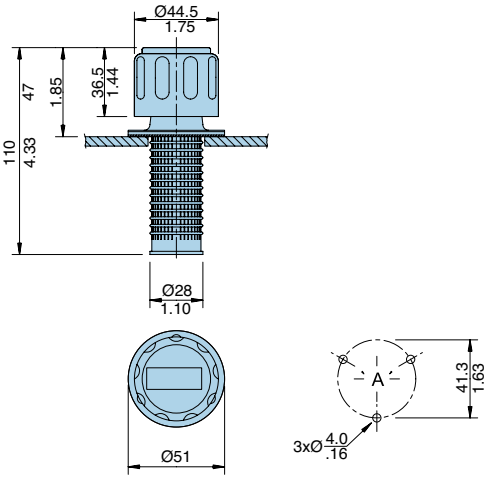
Seals: Nitrile.

Pressurization Options: none, 5 psi (0.35 bar).

3" Diameter



1.75" Diameter



Linear Measurement= mm / in

Flange Type, Non-pressurized

New Part No.	Obs. Part No.	New Part (Cap As.)	Obs. Part (Cap As.)	Micron Rtg	Air Flow	Description	Screws
AB.1163.10	MB1.D1A1B1P	CAP.1163.10	CP1.D1A1A1P	10	2 gal./sec. (7.5 l/sec.)	3" (76 mm) dia.	(6)-M10x.5
5561	MB1.D1A1B2P	Not Available	Not Available	10	2 gal./sec. (7.5 l/sec.)	3" (76 mm) dia., w/lck lug	(6)-M10x.5
AB.1380.10	MB1.A1A1B1P	CAP.1380.40	CP1.A2A1A1P	10	1.3 gal./sec. (5 l/sec.)	1.75" (44.5 mm) dia.	(6)-M10x.5

Flange Type, Pressurized

New Part No.	Obs. Part No.	New Part (Cap As.)	Obs.Part (Cap As.)	Micron Rtg.	Air Flow	Description	Screws
PAB.1730.10.5	MB1.D1C1B1P	CAP.1730.40.5	CP1.D1C1A1P	10	2 gal./sec. (7.5 l/sec.)	5 psi (.35 bar), 3" (76 mm)dia.	(6)-M10x.5

Metal Breathers

Threaded Type

Specifications:

Materials:
Cap & Plate: Nickel chrome plated steel.
Valve: Nylon/Nitrile.

Gasket: Cork.

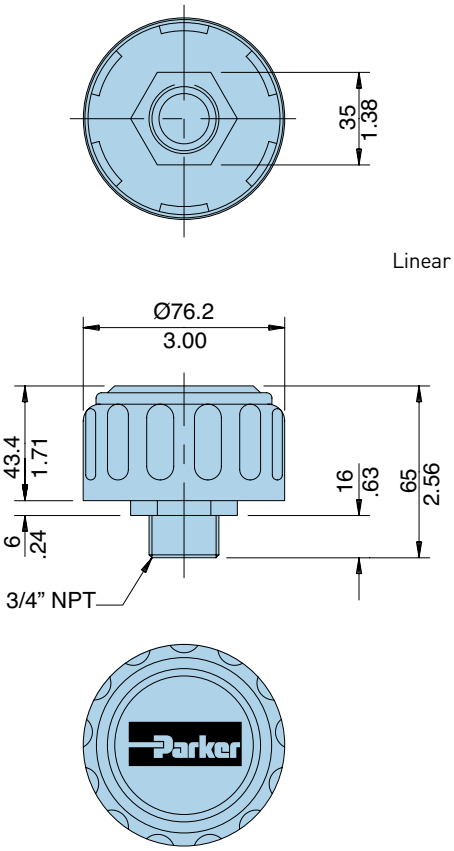
Filtration Element: Expanded polyurethane foam, 10 micron.

Operating Temperatures: -22°F (-30°C) to 195°F (90°C).

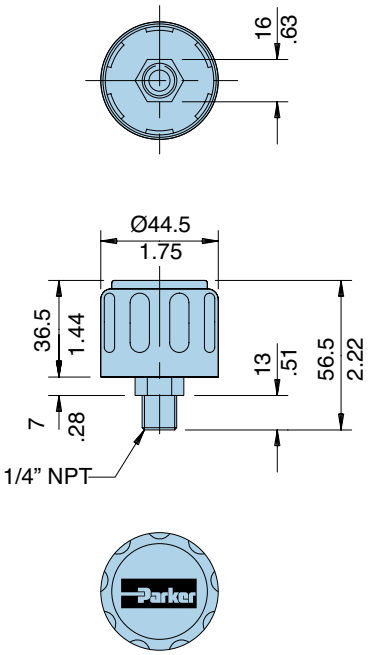
Seals: Nitrile.

Pressurization Options: none, 5 psi (0.35 bar).

¾" Threaded



¼" Threaded



Linear Measurement= mm / in

Threaded, Non-pressurized

New Part Number	Obs. Part Number	Micron Rating	Air Flow	Thread	Description
SAB.1562.10.NPT	MB1.B1A3A1P	10	1.3 gallon/sec. (5 l/sec.)	3/4" NPT	3" (76 mm) diameter
SAB.1563.10.NPT	MB1.C1A3A1P	10	.7 gallon/sec. (2.5 l/sec.)	1/4" NPT	1.75" (44.5 mm) diameter

Threaded, Pressurized

New Part Number	Obs. Part Number	Micron Rating	Air Flow	Thread	Description
SPA.1731.10.5.NPT	MB1.B1C3A1P	10	2 gallon/sec. (7.5 l/sec.)	3/4" NPT	5psi (.35 bar) with 3" (76 mm) diameter

Parker Hannifin Corporation
Hydraulic Filter Division
Metamora, OH

Breathers

Desiccant Type

Specifications:

Materials:
Casing: Clarified copolymer polypropylene.
Cap: Copolymer polypropylene.
Stand pipe: PVC.

Filtration Element: Polyester, silica gel.

Operating Temperatures: -20°F (-29°C) to 250°F (121°C).

Seals: None.

Maximum Allowable Operating Pressure (MAOP): 5 psi (.34 bar).

Particle Removal Efficiency:
98.7% (beta 75) @ 3 micron
99.5% (beta 200) @ 4 micron
99.9% (beta 1000) @ 5.3 micron

Weight:

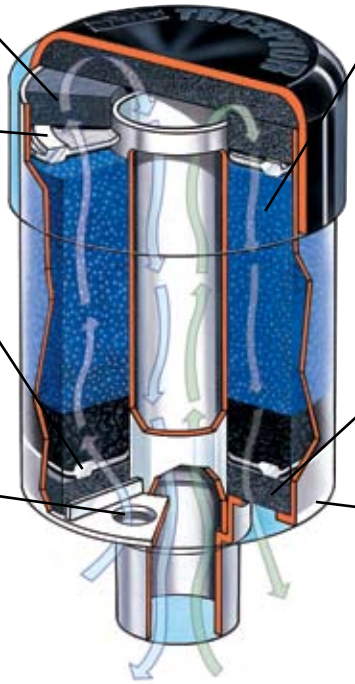
934330T	1.25 lbs. (.57 kg) each.
934331T	1.75 lbs. (.79 kg) each.
934332T	2.25 lbs. (1.02 kg) each.

Features

Foam Pads
Isolates the removal materials from contact with heavy reservoir mist and securely holds materials in place.

Filter Pads
Specially designed filter pads remove solid particulate on upstream side and then regenerate by releasing those particles when air flow reverses direction. Lower pad removes airborne contamination and second pad protects against any migration of desiccant.

Air Intakes
A total of eight air intakes may be exposed to allow air to freely flow in and out of the TriCeptor.



Silica Gel Desiccant
Has the highest removal capability by volume of any adsorption method. Indicates condition by changing color.

Foam pad
Insures filter pad is properly positioned and protects it from external damage.

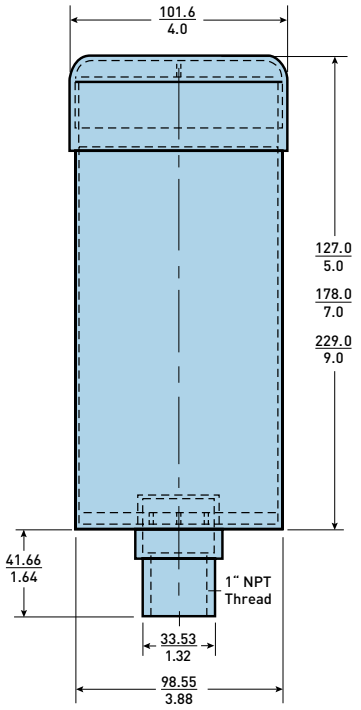
Molded Housing
Durable shock absorbing casing provides reliable service and simple press in mounting.

Installation

TriCeptor breathers are designed for simple installation on most equipment, regardless of mounting connection. Since TriCeptor breathers are disposable, the threaded connection allows for quick and easy maintenance. Several mounting adapters (shown below) are available to provide the desired mounting. The installation/replacement process consists of four easy steps:

1. Remove from protective plastic wrap.
2. Remove 1" blue cap from standpipe.
3. Remove foil label to expose the necessary amount of air intake holes.
4. Twist TriCeptor into mounting adapter.

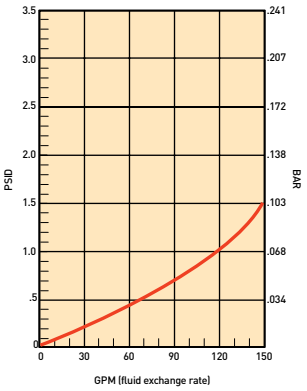
Servicing the TriCeptor breather is also very easy. When the silica gel changes color from blue to a pink, the breather is no longer active and needs to be replaced. Simply remove the unit and discard properly.

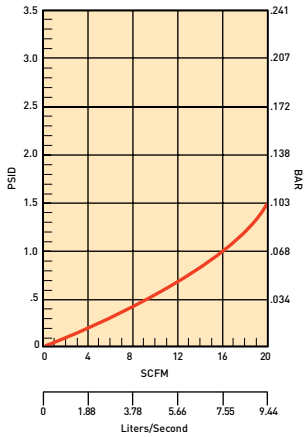


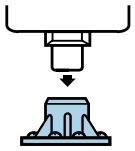
Linear Measurement= $\frac{mm}{in}$

Air Flow Performance

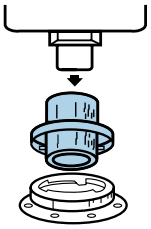
The curves below show the air flow performance of the three TriCeptor breathers. To insure the longest life possible, the initial clean pressure drop should not exceed 1.5 psid (.103 bar).







Field Adapter



Flange Adapter

Model	Part Number	Quantity
5" Breather	934330T	6 pcs.
7" Breather	934331T	6 pcs.
9" Breather	934332T	6 pcs.
Field Adapter	937546	1 pc.
Flange Adapter	937463	1 pc.

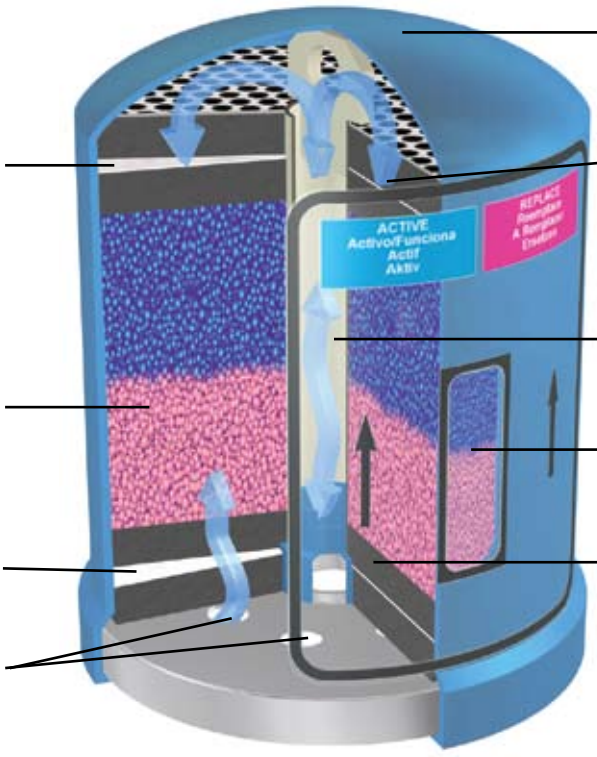
Parker Hannifin Corporation
Hydraulic Filter Division
Metamora, OH

Reservoir Accessories
Breathers

Parker's newest air breather is well suited for heavy duty industrial and mobile applications. This new design is equipped to handle high air flow surges as cylinders discharge while providing reliable protection from ingressed water vapor and particulates for clean dry fluids.
This also interchanges Pall's PFD8 series desiccant breather.

Part Number (air breather):	937346
Check vavle breather adaptor:	937347
Dimensions (height x dia):	6.5 in. (165mm) x 5 in. (127mm)
Filtration area:	38 in^2 (0.025 m^2)
Amount of silica gel:	24 oz. (680 g)
Absorption capacity:	9 0z. (266 ml)
Max. flow rate:	20 cfm @ 1 psid
Filtration:	1µm
Operating temp. range:	-20^0 F (-29^0 C) to +250^0 F (+121^0 C)
Hydrophilic agent:	Indicating silica gel
Filter media:	Polyester/Microglass

Optional breather check valve adator extends breather service life.



Second filter element protects against any migration of desiccant dust.

Color indicating silica gel, absorbs water from incoming air. During exhalation, dry system air is passed back through the silica gel bed partially regenerating the desiccant.

High performance filter element provides 1-micron filtration.

Air inlets are open to meet system requirements, providing "controlled" breathing. This maximizes the lifespan of breather.

Rugged aluminum housing.

Foam pad stops oil mist and ensures air is evenly disbursed through the filters and desiccant, providing maximum efficiency for "backflushing" and silica gel regeneration.

Stainless steel standpipe.

Visual indicator window. Replace breather when desiccant color changes from blue to pink.

Foam pads evenly disperse incoming air over filtration and drying media.

*Patented technology

Parker Hannifin Corporation
Hydraulic Filter Division
Metamora, OH

Breathers

Spin-on Type

Specifications:

Materials: Low carbon steel.

Filtration Element: Cellulose.

Operating Temperatures:
-40°F (-40°C) to 225°F (107°C).

Seals: Nitrile.

Weight: 12AT - 1.2 lbs(.54 kg) each.
50AT - 2.3 lbs. (1.0 kg) each.

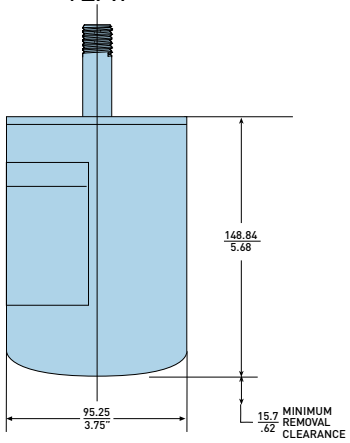
Sizing

Select the proper size cannister for the maximum rate of reservoir draw down or air exchange rate. As a rule of thumb, clean pressure drop should be limited to 0.18 psid (5" H_2O).

Recommended cannister change out is after 500 hours of operation. More frequent replacement may be required when operated in heavily contaminated areas such as grinding operations, primary metal mills, and on mobile equipment. Under such conditions, increase replacement frequency to every 250 hours.

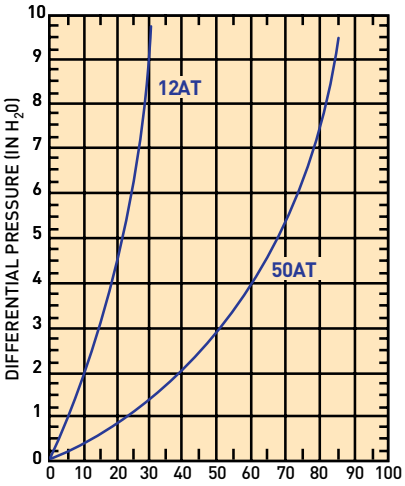
12AT

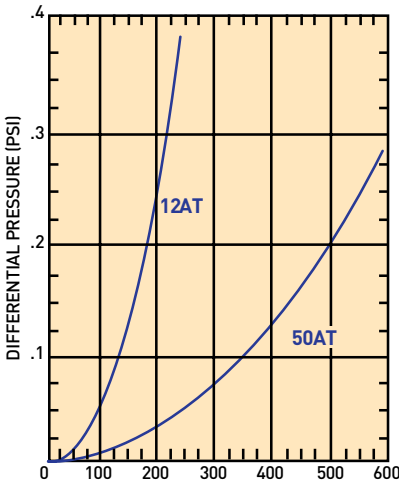
Linear Measurement= $\frac{mm}{in}$

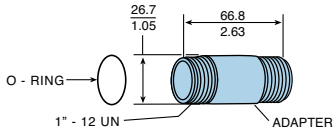


Graphs are for 03C cannisters only. Total pressure drop across cannister, adaptor, and pipe may be found by adding pressure drops below:

+ 1.5% for each inch of 12AT adapter or 3/4" pipe used.
+ 3.0% for each 3/4" elbow used.
+ 1.0% for each inch of 50AT adapter or 1-1/4" pipe used.
+ 2.0% for each 1-1/4" elbow used.

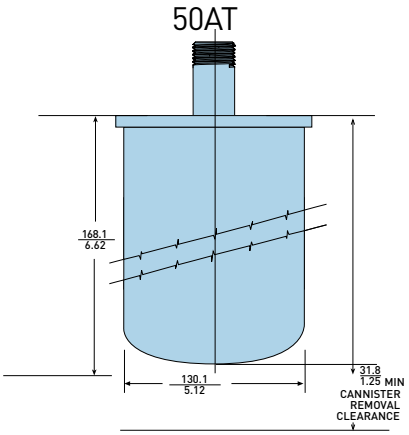


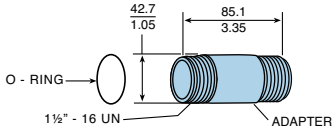




P/N 926876

50AT





P/N 926875

Element	Air Rating*	Diameter	Adaptor Kit
926543	1 micron	3.75"	926876
921999	2 micron	3.75"	926876
925023	5 micron	3.75"	926876
926541	1 micron	5.1"	926875
926169	2 micron	5.1"	926875
926170	5 micron	5.1"	926875

*99% removal efficiency for particles larger than stated size in air.

Parker Hannifin Corporation
Hydraulic Filter Division
Metamora, OH

Diffusers

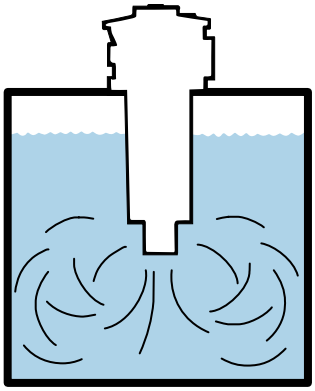
Specifications:

Operating Temperatures: 195°F (90°C) maximum.

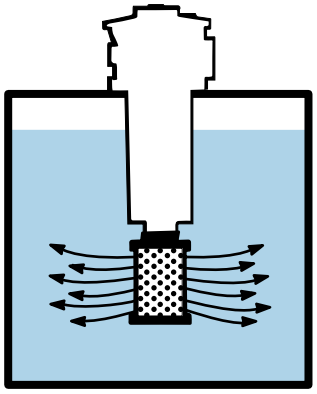
Materials: Body & end cap: Zintec.
Head: glass-filled nylon.

Weight: See chart below.

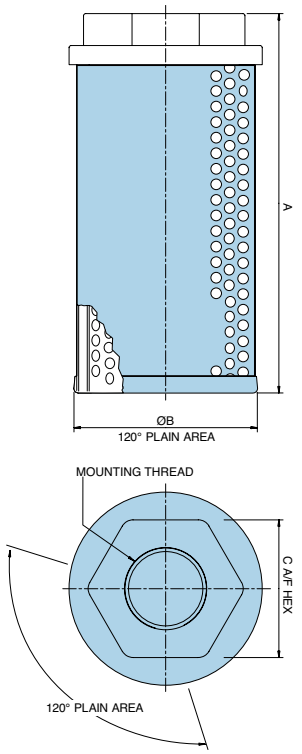
Benefits:
Installing a diffuser in a hydraulic reservoir is a simple change that can make a dramatic difference in system efficiency. With special concentric tubes designed with discharge holes 180° opposed, fluid aeration, foaming and reservoir noise are reduced. Pump life is also extended by reducing cavitation to the pump inlet. The effects of fitting a system with a diffuser are shown below.



Flow without diffuser



Flow with diffuser fitted



New Part Number	Obs. Part Number	Thread (NPT)	Nominal Flow GPM (LPM)	Length "A" Inch (mm)	Diameter "B" Inch (mm)	HEX "C" Inch (mm)	Weight Lbs. (kg)
2250	DF1.A2BP	3/4"	13 (50)	4.7 (120)	2.4 (62)	1.81 (46)	.60 (0.27)
2251	DF1.B4BP	1"	30 (114)	5.0 (127)	3.4 (86)	2.17 (55)	.93 (0.42)
2252	DF1.B6BP	1 1/2"	60 (227)	7.0 (178)	3.4 (86)	2.56 (65)	1.23 (0.56)
2253	DF1.B9BP	2"	120 (454)	9.5 (242)	3.4 (86)	2.95 (75)	1.52 (0.69)

Fluid Level/ Temperature Gauges

Specifications:

Materials:
Lens: Transparent polyamide.
Lens base: Nylon 66.
Shroud: High impact polystyrene (no aluminum content).

Seals: Nitrile.

Maximum Operating Pressure: 14.7 psi (1 bar).

Operating Temperatures: -22°F (-30°C) to 195°F (90°C).

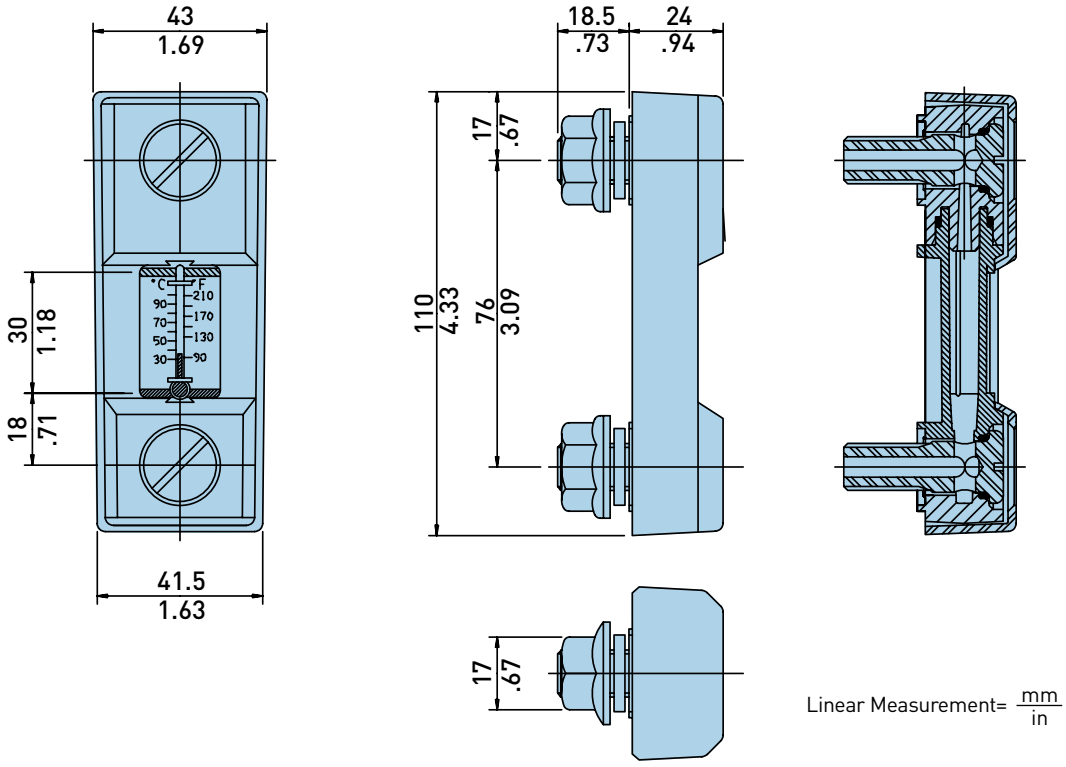
Thermometer Range: 90°F to 210°F (30°C to 90°C).

Indicator: Blue alcohol.

Fluid Compatibility: Mineral and petroleum based fluids.

Mounting: Front or rear fixing, two holes (M10).

Length 3



Linear Measurement= $\frac{mm}{in}$

Part Number	Thread	Length	Description
FL.69121	M10	3	Fluid level and temperature
FL.69221	M10	5	Fluid level and temperature
FL.69321	M10	10	Fluid level and temperature

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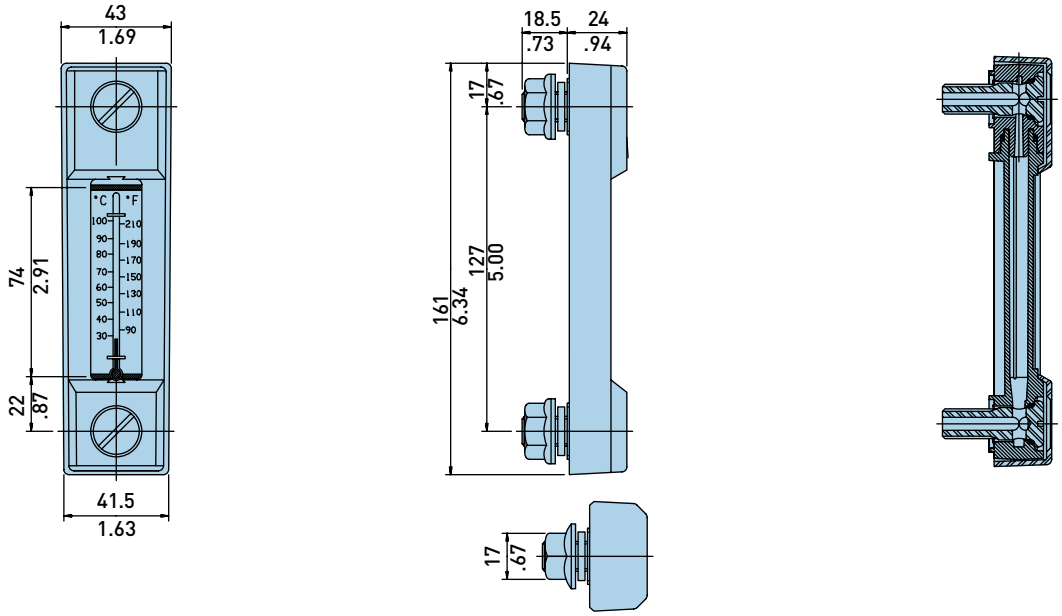
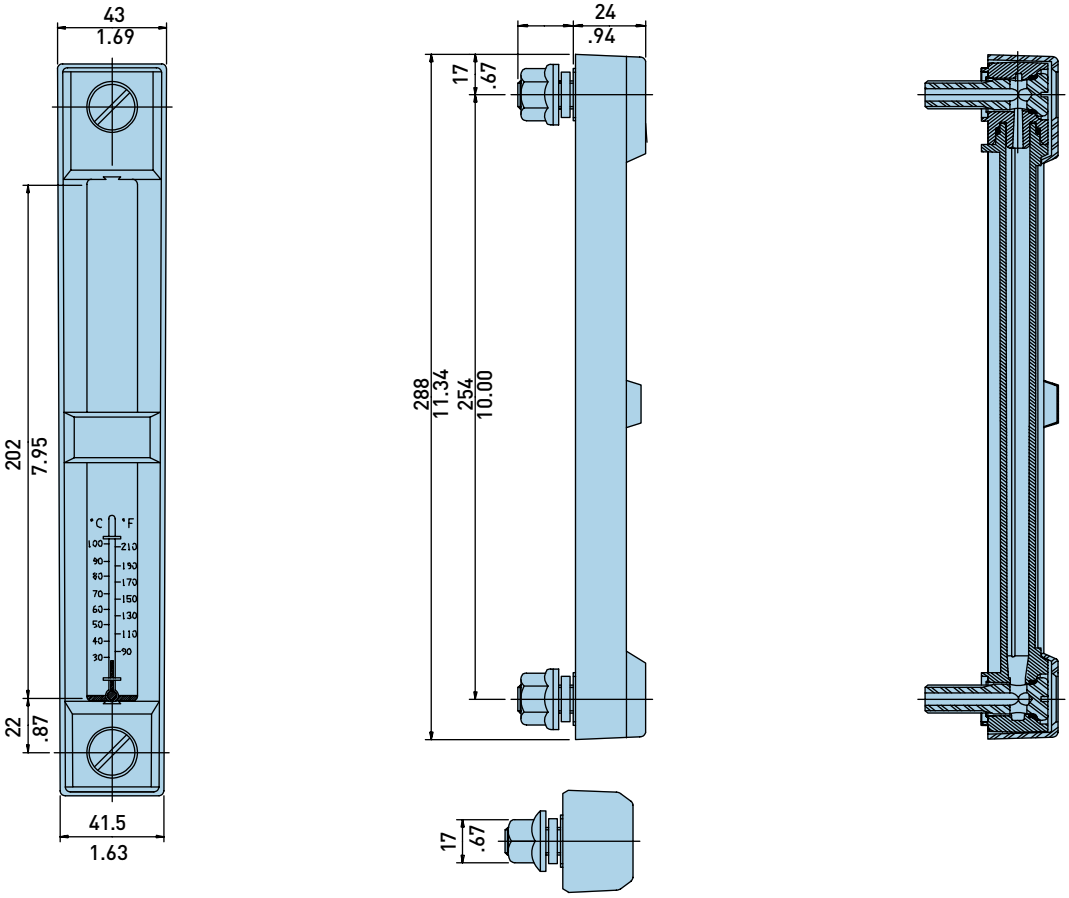
Hydraulic Filter Division
Metamora, OH

Length 5



Length 10



Linear Measurement= $\frac{mm}{in}$

Suction Strainers

Specifications:

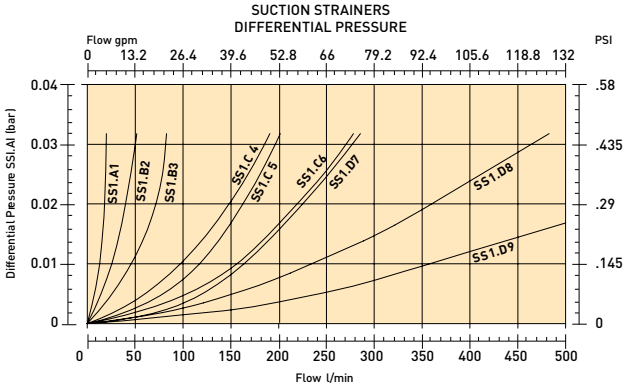
Materials:
Media: Stainless steel.
Tube and endcap: Zintec.
Head: glass filled nylon.

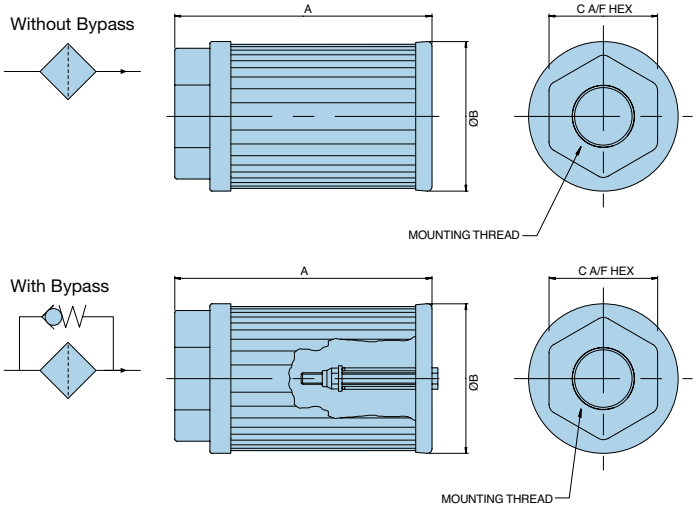
Filtration Element: 100 mesh (149 micron).

Operating Temperatures: 195°F (90°C) maximum.

Bypass: None, 3 psi (0.2 bar).

Weight: See chart below.





New Part No. With Bypass	Obs. Part No. With Bypass	New Part No. W/out Bypass	Obs. Part No. W/out Bypass	Port (NPT)	Nominal Flow GPM (LPM)	Length "A" Inch (mm)	Diameter "B" Inch (mm)	Hex "C" Inch (mm)	Weight Lbs. (kg)
937481	SE.75112111	937480	SE.75112110	1/2"	5 (19)	3.10 (78.7)	2.67 (67.8)	1.42 (36)	0.4 (18)
937483	SE.75222111	937482	SE.75222110	3/4"	8 (30)	3.55 (90.2)	2.67 (67.8)	1.81 (46)	0.5 (.23)
937485	SE.75232211	937484	SE.75232210	1"	10 (38)	5.35 (135.9)	2.67 (67.8)	2.17 (55)	0.7 (.32)
937487	SE.75352211	937486	SE.75352210	1 1/2"	30 (114)	8.01 (203.5)	3.47 (88.1)	2.56 (65)	1.2 (.54)
937489	SE.75352311	937488	SE.75352310	1 1/2"	50 (189)	9.85 (250.2)	4.00 (101.6)	2.56 (65)	1.4 (6.4)
937491	SE.75362411	937490	SE.75362410	2"	50 (189)	9.85 (250.2)	4.00 (101.6)	2.95 (75)	1.8 (.82)
937495	SE.75472311	937494	SE.75472310	2 1/2"	75 (284)	10.1 (256.6)	5.17 (131.3)	3.54 (90)	2.3 (1.04)
937497	—	937496	—	3"	100 (378)	11.8 (299.7)	5.17 (131.3)	3.94 (100)	3.0 (1.36)

Parker Hannifin Corporation
Hydraulic Filter Division
Metamora, OH

Magnetic Suction Strainers
Now offer dual protection, without cavitation!

Parker's new magnetic suction strainers offer dual protection to the pump inlet without risk of cavitation.

Powerful ceramic magnets located parallel to the pleated mesh attract and protect against damaging ferrous particles of all sizes.

The pleated stainless steel screen provides additional filtration protection for larger particles that would result in catastrophic failure.

The generous open area of the stainless steel pleated mesh screen elimantes the possibility of pump cavitation.

Parkers magnetic suction strainers are available in sizes ranging from one to three inches.

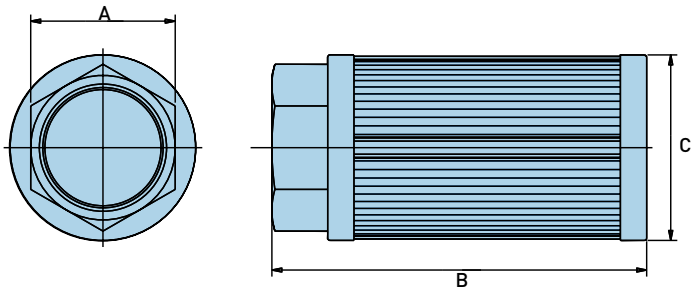
Ordering Information

The information below shows the part numbers, specifications and dimensions of available suction strainers, to help you meet the needs of your specific application.

NOTE: All sizes are standard with 30 mesh screen (560 micron).

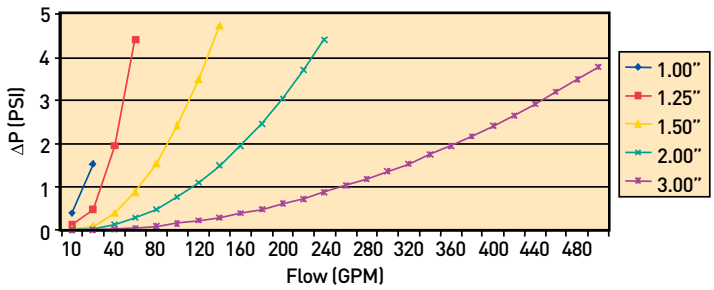
Part Number	NPT Connection	Flow GPM (LPM)	Dimensions			Approx. Shipping Weight lbs. (kg)
			A inches (mm)	B inches (mm)	C inches (mm)	
936547	1.00"	15 (55)	1.88 (47.75)	5.19 (131.83)	3.09 (78.49)	1.59 (0.72)
936548	1.25"	25 (95)	2.38 (60.45)	7.39 (187.71)	3.53 (89.66)	3.16 (1.43)
936549	1.50"	35 (135)	2.38 (60.45)	7.39 (187.71)	3.53 (89.66)	2.88 (1.31)
936550	2.00"	50 (190)	2.75 (69.85)	7.39 (187.71)	3.53 (89.66)	2.22 (1.01)
936551	3.00"	100 (380)	*	9.35 (237.49)	4.47 (113.54)	3.91 (1.77)

*Part number 936551 features a 3" half coupling, not a hex nut.

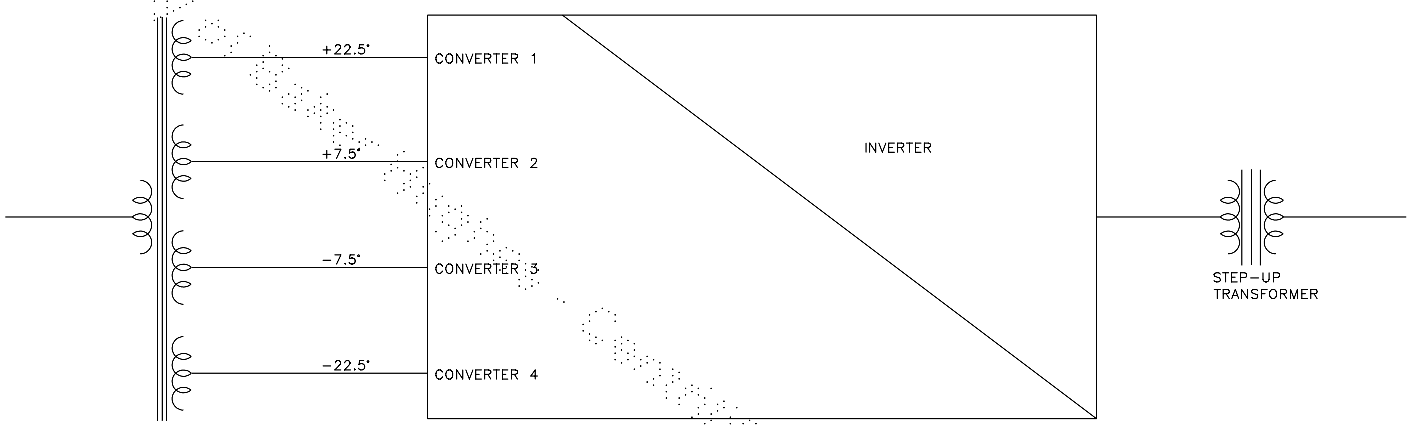


The rugged steel construction, combined with the generous filtration area, ensures reliable performance for suction applications

Flow Vs. Pressure Loss



Parker Hannifin Corporation
Hydraulic Filter Division
Metamora, OH



24 PULSE ELECTROSPEED GCS

NOTES:

1. THE ELECTROSPEED GCS IN A TWENTY−FOUR PULSE CONFIGURATION CONSISTS OF FOUR CONVERTER SECTIONS THAT EACH CONDUCTS TWENTY−FIVE PERCENT OF THE DRIVE INPUT CURRENT. EACH CONVERTER SECTION IS CONNECTED TO A 480 VOLT SOURCE THAT IS PHASE SHIFTED FROM THE OTHER CONVERTERS. THE PHASE SHIFT BETWEEN THE CONVERTERS IS FIFTEEN DEGREES. THIS PHASE SHIFTING OF THE POWER TO THE CONVERTERS IS DONE THROUGH A SPECIALTY TRANSFORMER. THE RESULTS OF THE HARMONIC CANCELLATION USING THIS SCHEME IS A TOTAL CURRENT DISTORTION INTO THE DRIVE OF ABOUT 3%. THIS WILL VARY SLIGHTLY DEPENDING ON THE POWER SYSTEM IMPEDANCE.

REV.	DATE	REVISION	DWN BY	CHK BY	APP BY	PCN NO.
A	14OCT03	PROD RLSE	DWC	K.K.	K.K.	17807

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. INTERPRET THIS DRAWING PER ANSI Y14.5M−1982
2. BREAK ALL SHARP CORNERS.
3. ALL DIMENSIONS IN INCHES. DO NOT SCALE PRINT.
4. ALL RUST, SCALE AND DEBRIS MUST BE REMOVED. SURFACE RUST, ONLY, ALLOWED ON CAST SURFACES.
5. TOLERANCES:

		MACHINED	FORMED
FRACTIONAL		±1/64"	
DECIMAL	.X	±.015	
	.XX	±.010	±.020 HOLE PATTERNS
			±.060 TO BEND LINES
	.XXX	±.003	±.030 TO BEND LINES
ANGULAR		±0.5°	±1.0°
ROUGH CAST		±.015/IN	
INVESTM'T CAST		±.005/IN	

MATERIAL: −
NEXT ASM: −
THIRD ANGLE PROJECTION

BAKER HUGHES Centrilift
Control Technologies

24 PULSE ELECTROSPEED GCS UNITS

SCALE: 1 = 2	DATE	SIZE D	125/ ALL OVER EXCEPT AS NOTED
DWN BY: DW CATES	14OCT03		SHEET NUMBER 1 OF 1
CHK BY: K.KABRICH	14OCT03		DRAWING NUMBER 902583
APP BY: K.KABRICH	14OCT03		REV. A

NO. 61200928.516

C902676

PULSAR24-SRC™

THIS TRANSFORMER IS DESIGNED SPECIFICALLY TO INTERFACE BETWEEN A TWENTY-FOUR PULSE SRC TYPE CONVERTER AND AN ELECTRIC POWER SOURCE WHERE THE CONVERTER FORCES THE LOAD TO REMAIN BALANCED.

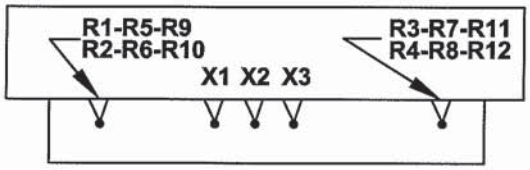
UNBALANCED LOAD WILL CAUSE EXCESSIVE HEAT

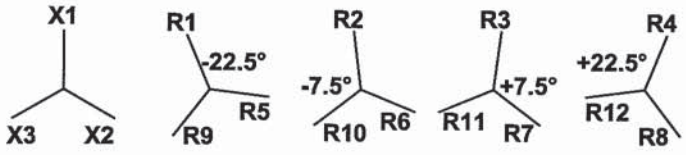
750 KVA 3 PHASE 60 HERTZ 65°C RISE

	VOLTS	AMPS	CONDUCTOR	BIL
X1-X2-X3	480	910	CU	30
R1-R5-R9	484	226	AL	30
R2-R6-R10	484	226	AL	30
R3-R7-R11	484	226	AL	30
R4-R8-R12	484	226	AL	30

239 GAL. MINERAL OIL NON-PCB CLASS OA
TANK IS DESIGNED FOR 7 PSIG
OIL LEVEL IS 7" BELOW THE LID AT 25°C
OIL LEVEL CHANGES 0.37" PER 10°C

TOTAL MASS	3873 LB.
OIL MASS	1793 LB.
UNTANKING MASS	1252 LB.
TANK AND FITTINGS MASS	828 LB.





TAPS

GENERAL TOLERANCES (UNLESS OTHERWISE SPECIFIED
LINEAR .063 IN (1/16) WIEDAMATIC .031 IN
DIAGONAL .093 IN (3/32) PORCELAIN .03 PER IN

REV.	DATE	REVISION	BY	APP.
A	12/27/07	Changed weights and oil volume, issued as record.	JS	JS

TAPS
TAPS MANUFACTURING, INC.
MADE IN USA
ISO 9001 REGISTERED

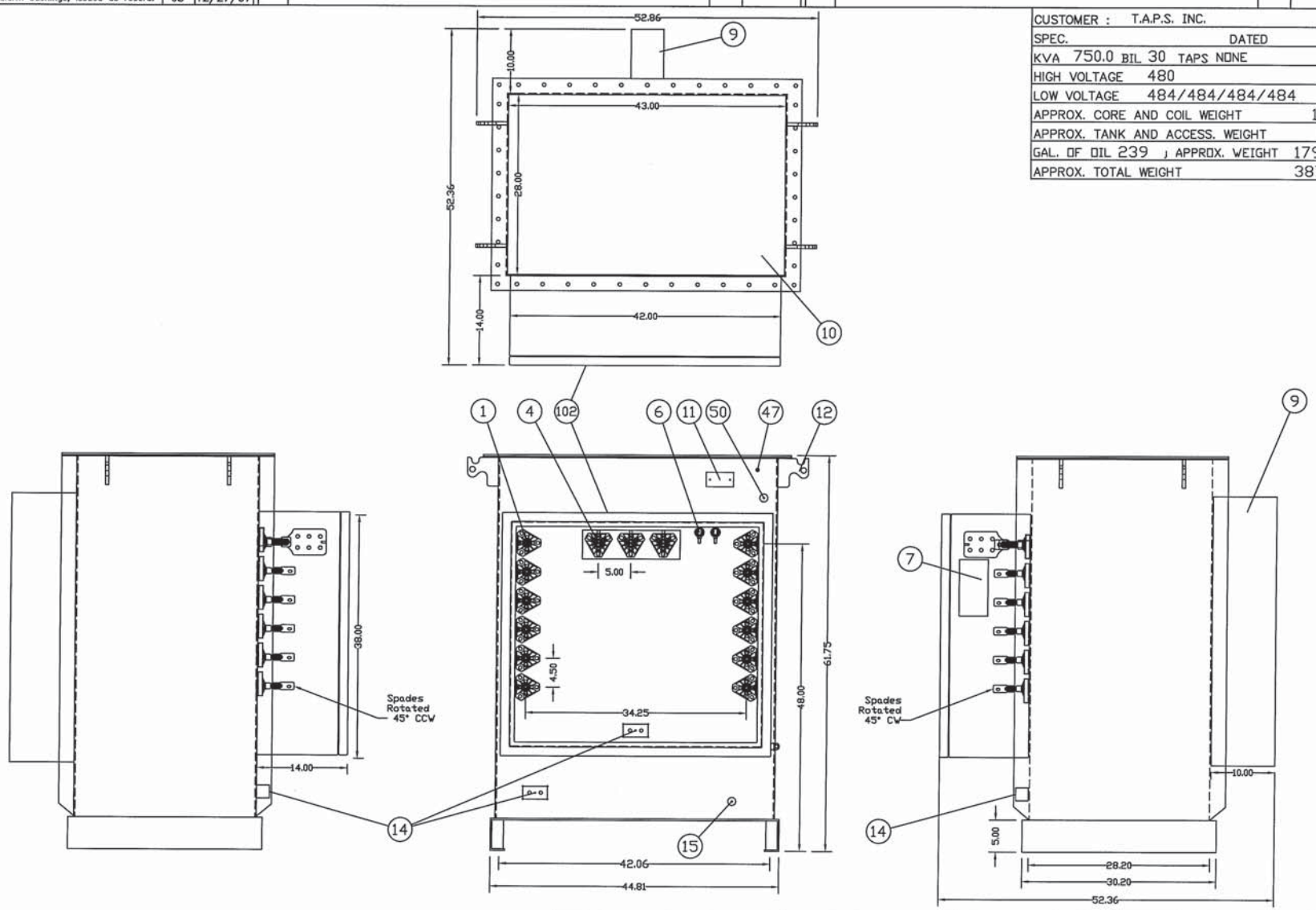
NAME: T.A.P.S. NAMEPLATE 1		C.C. 714	
DESCR: 9989460380032			
3JRS5901		61200928.516	
SCALE 1.000	DWG BY JS	CHK BY	DATE 12/12/07

REV	DESCRIPTION	BY	DATE
A	Increased tank and junction box width, re-located WT alarm bushings, issued as record.	JS	12/27/07

	DESCRIPTION
1	LVB 30BIL HI .625" STUD WITH 1H SPADE AND #2 TO 500MCM LUG
4	TAPS 30KV BIL 1" STUD AND 6 HOLE SPADE
6	WINDING TEMP. ALARM BUSHING
7	NAMEPLATE
9	COOLING RADIATORS
10	BOLTED COVER
11	SERIAL NUMBER PLATE
12	LIFTING LUGS
14	2 HOLE HORIZ NEMA GRD PAD
15	1 IN DRAIN PLUG
47	PRESS. REL VALVE
50	OIL LEVEL PLUG

	SPECIAL NOTES
A	
B	
C	
D	
E	

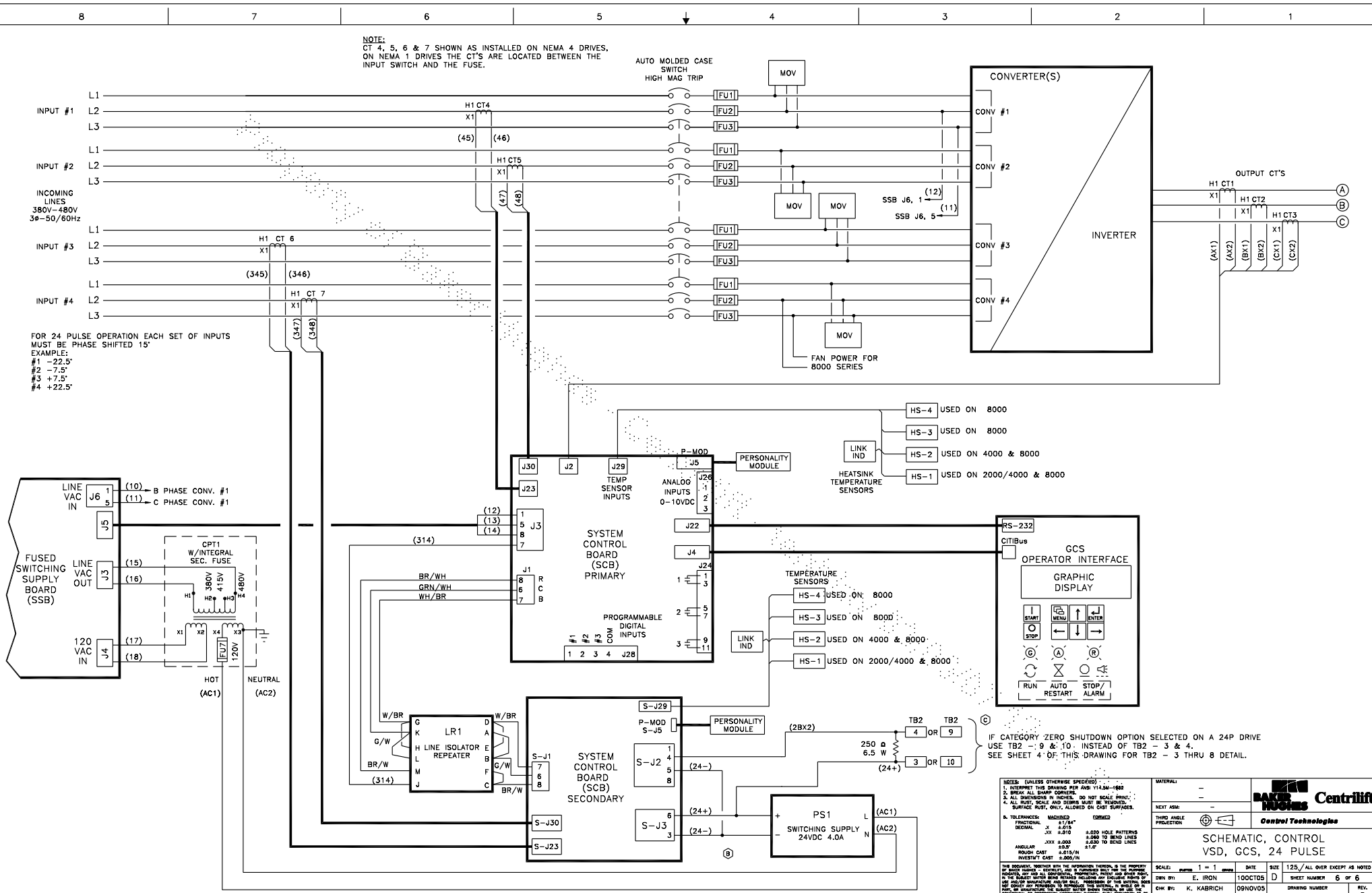
CUSTOMER :	T.A.P.S. INC.
SPEC.	DATED
KVA	750.0 BIL 30 TAPS NONE
HIGH VOLTAGE	480
LOW VOLTAGE	484/484/484/484
APPROX. CORE AND COIL WEIGHT	1252
APPROX. TANK AND ACCESS. WEIGHT	828
GAL. OF OIL 239 , APPROX. WEIGHT	1793
APPROX. TOTAL WEIGHT	3873



XX9999999 $7SBA859

TAPS
TAPS MANUFACTURING, INC.
MADE IN USA
ISO 9001 REGISTERED

NAME:	CENTRILIFT P/N 902676	CC	745
CAT. NO.	9989460380032		
ID.	3JRS5915	PN.	368061-7639
SCALE	0.064	DWG BY JS	CHK BY DATE: 12/12/07



NOTES: (UNLESS OTHERWISE SPECIFIED)
1. INTERPRET THIS DRAWING PER ANSI Y14.5M–1982
2. BREAK ALL SHARP CORNERS.
3. ALL DIMENSIONS IN INCHES. DO NOT SCALE PRINT.
4. ALL RUST, SCALE AND DEBRIS MUST BE REMOVED. SURFACE RUST, ONLY, ALLOWED ON CAST SURFACES.

	MACHINED	FORMED
FRACTIONAL	±1/64"	
DECIMAL .X	±.015	
.XX	±.010	±.030 HOLE PATTERNS ±.060 TO BEND LINES
.XXX	±.003	±.030 TO BEND LINES
ANGULAR	±0.5°	±1.0°
ROUGH CAST	±.015/IN	
INVESTMENT CAST	±.005/IN	

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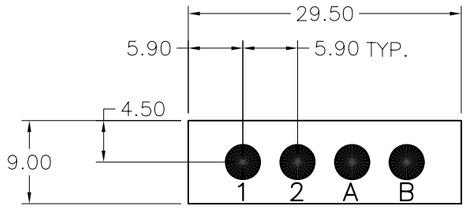
MATERIAL: –
NEXT ASM: –
THIRD ANGLE PROJECTION

BAKER HUGHES Centrilift
Control Technologies

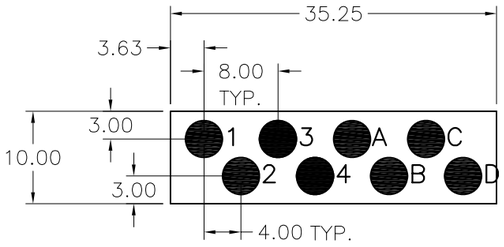
SCHEMATIC, CONTROL
VSD, GCS, 24 PULSE

SCALE: 1 = 1	DATE	SIZE	125 ALL OVER EXCEPT AS NOTED	
DRN BY: E. IRON	10OCT05	D	SHEET NUMBER 6 OF 6	
CHK BY: K. KABRICH	09NOV05	DRAWING NUMBER 901437		REV. C
APP BY: S. HULTS	09NOV05			



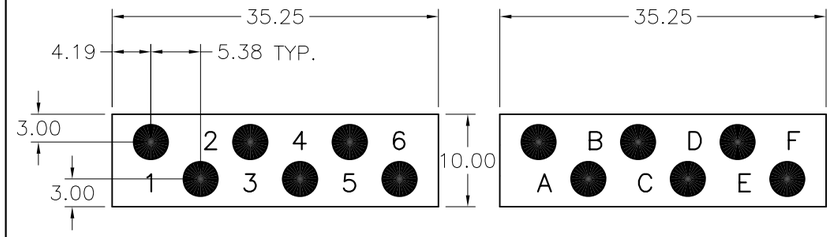
GLAND PLATE
2000 SERIES NEMA 4, GCS

DRIVE SIZE	USE HOLES	HOLE DIA.	
2060–6P	1 & A	1" CONDUIT	
2075–6P	1 & A	1–1/4" CONDUIT	
2100–6P	1 & A	1–1/2" CONDUIT	
2125–6P	1 & A	1–1/2" CONDUIT	
2150–6P	1,2 & A,B	1–1/4" CONDUIT	
2200–6P	1,2 & A,B	1–1/4" CONDUIT	
2250–6P	1,2 & A,B	1–1/2" CONDUIT	
2060–12P	1 & A,B	1/2" CONDUIT	SEE NOTE 1.
2075–12P	1 & A,B	3/4" CONDUIT	SEE NOTE 1.
2100–12P	1 & A,B	3/4" CONDUIT	SEE NOTE 1.
2125–12P	1 & A,B	1–1/4" CONDUIT	SEE NOTE 1.
2150–12P	1 & A,B	1–1/4" CONDUIT	SEE NOTE 1.
2200–12P	1 & A,B	1–1/4" CONDUIT	SEE NOTE 1.
2250–12P	1 & A,B	1–1/2" CONDUIT	SEE NOTE 1.



GLAND PLATE
4000 SERIES NEMA 4, GCS

DRIVE SIZE	USE HOLES	HOLE DIA.
4300–6P	1,2,3 & A,B,C	1–1/2" CONDUIT
4350–6P	1,2,3 & A,B,C	1–1/2" CONDUIT
4400–6P	1,2,3 & A,B,C	2" CONDUIT
4500–6P	1,2,3 & A,B,C	2" CONDUIT
4300–12P	1,2,3,4 & A,B,C,D	1–1/4" CONDUIT
4350–12P	1,2,3,4 & A,B,C,D	1–1/4" CONDUIT
4400–12P	1,2,3,4 & A,B,C,D	1–1/2" CONDUIT
4500–12P	1,2,3,4 & A,B,C,D	1–1/2" CONDUIT



INPUT GLAND PLATE
8000 SERIES NEMA 4, GCS

OUTPUT GLAND PLATE
8000 SERIES NEMA 4, GCS

DRIVE SIZE	USE HOLES	HOLE DIA.
8600	ALL	1–1/4" CONDUIT
8700	ALL	1–1/2" CONDUIT
8800	ALL	2" CONDUIT
8900	ALL	2" CONDUIT

NOTES:

1. CABLES FOR 12 PULSE ARE SHOWN FOR (2) INPUT SWITCHES. FOR ONE INPUT SWITCH USE 6 PULSE CABLE SIZES, LUG KITS, TORQUE & CABLE GLANDS.
2. NUMERIC CHARACTERS ARE THE INPUTS AND ALPHA CHARACTERS ARE FOR OUTPUT.
3. SEE APPENDIX D IN MANUAL FOR CABLES, GLANDS & LUG SIZES.
4. FOR GLAND PLATE LOCATION:
   2000 SERIES SEE 900997
   4000 SERIES SEE 900995
   8000 SERIES SEE 901191

REV.	DATE	REVISION	DWN BY	CHK BY	APP BY	PCN NO.
A	20JAN03	PROD RLSE	EI	JF	KK	17189

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. INTERPRET THIS DRAWING PER ANSI Y14.5M–1982
2. BREAK ALL SHARP CORNERS.
3. ALL DIMENSIONS IN INCHES. DO NOT SCALE PRINT.
4. ALL RUST, SCALE AND DEBRIS MUST BE REMOVED. SURFACE RUST, ONLY, ALLOWED ON CAST SURFACES.
5. TOLERANCES: MACHINED / FORMED
   FRACTIONAL ±1/64" /
   DECIMAL .X ±.015 /
   .XX ±.010 / ±.020 HOLE PATTERNS
   ±.060 TO BEND LINES
   .XXX ±.003 / ±.030 TO BEND LINES
   ANGULAR ±0.5° / ±1.0°
   ROUGH CAST ±.015/IN
   INVESTM'T CAST ±.005/IN

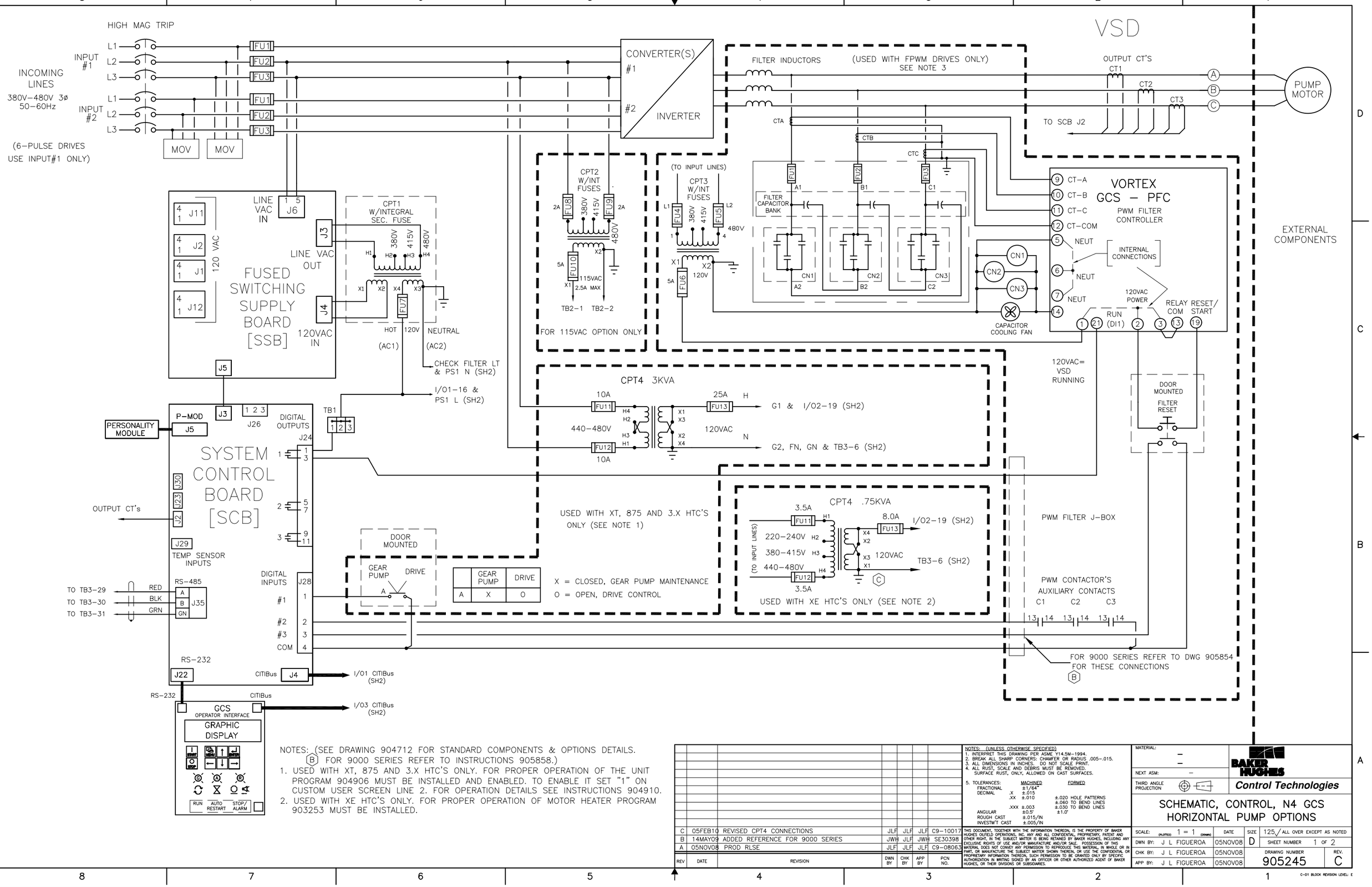
MATERIAL: –
–
NEXT ASM: –
THIRD ANGLE PROJECTION

BAKER HUGHES Centrilift
Control Technologies

GLAND PLATE, CONDUIT SIZE
2N4, 4N4 & 8N4, GCS

SCALE: (PLOTTED) 1 = 1 (DRAWN)	DATE	SIZE	125 ALL OVER EXCEPT AS NOTED
DWN BY: E. IRON	20JAN03	D	SHEET NUMBER 1 OF 1
CHK BY: J. FIGUEROA	22JAN03	DRAWING NUMBER 902223	REV. A
APP BY: K. KABRICH	22JAN03		

C–01 BLOCK REVISION LEVEL: C



NOTES: (SEE DRAWING 904712 FOR STANDARD COMPONENTS & OPTIONS DETAILS.
(B) FOR 9000 SERIES REFER TO INSTRUCTIONS 905858.)

1. USED WITH XT, 875 AND 3.X HTC'S ONLY. FOR PROPER OPERATION OF THE UNIT PROGRAM 904906 MUST BE INSTALLED AND ENABLED. TO ENABLE IT SET "1" ON CUSTOM USER SCREEN LINE 2. FOR OPERATION DETAILS SEE INSTRUCTIONS 904910.
2. USED WITH XE HTC'S ONLY. FOR PROPER OPERATION OF MOTOR HEATER PROGRAM 903253 MUST BE INSTALLED.

REV	DATE	REVISION	DWN BY	CHK BY	APP BY	PCN NO.
C	05FEB10	REVISED CPT4 CONNECTIONS	JLF	JLF	JLF	C9–10017
B	14MAY09	ADDED REFERENCE FOR 9000 SERIES	JWH	JLF	JWH	SE30398
A	05NOV08	PROD RLSE	JLF	JLF	JLF	C9–08063

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. INTERPRET THIS DRAWING PER ASME Y14.5M–1994.
2. BREAK ALL SHARP CORNERS: CHAMFER OR RADIUS .005–.015.
3. ALL DIMENSIONS IN INCHES. DO NOT SCALE PRINT.
4. ALL RUST, SCALE AND DEBRIS MUST BE REMOVED. SURFACE RUST, ONLY, ALLOWED ON CAST SURFACES.
5. TOLERANCES:

	MACHINED	FORMED
FRACTIONAL	±1/64"	
DECIMAL .X	±.015	
.XX	±.010	±.020 HOLE PATTERNS ±.060 TO BEND LINES
.XXX	±.003	±.030 TO BEND LINES
ANGULAR	±0.5'	±1.0'
ROUGH CAST	±.015/IN	
INVEST'M'T CAST	±.005/IN	

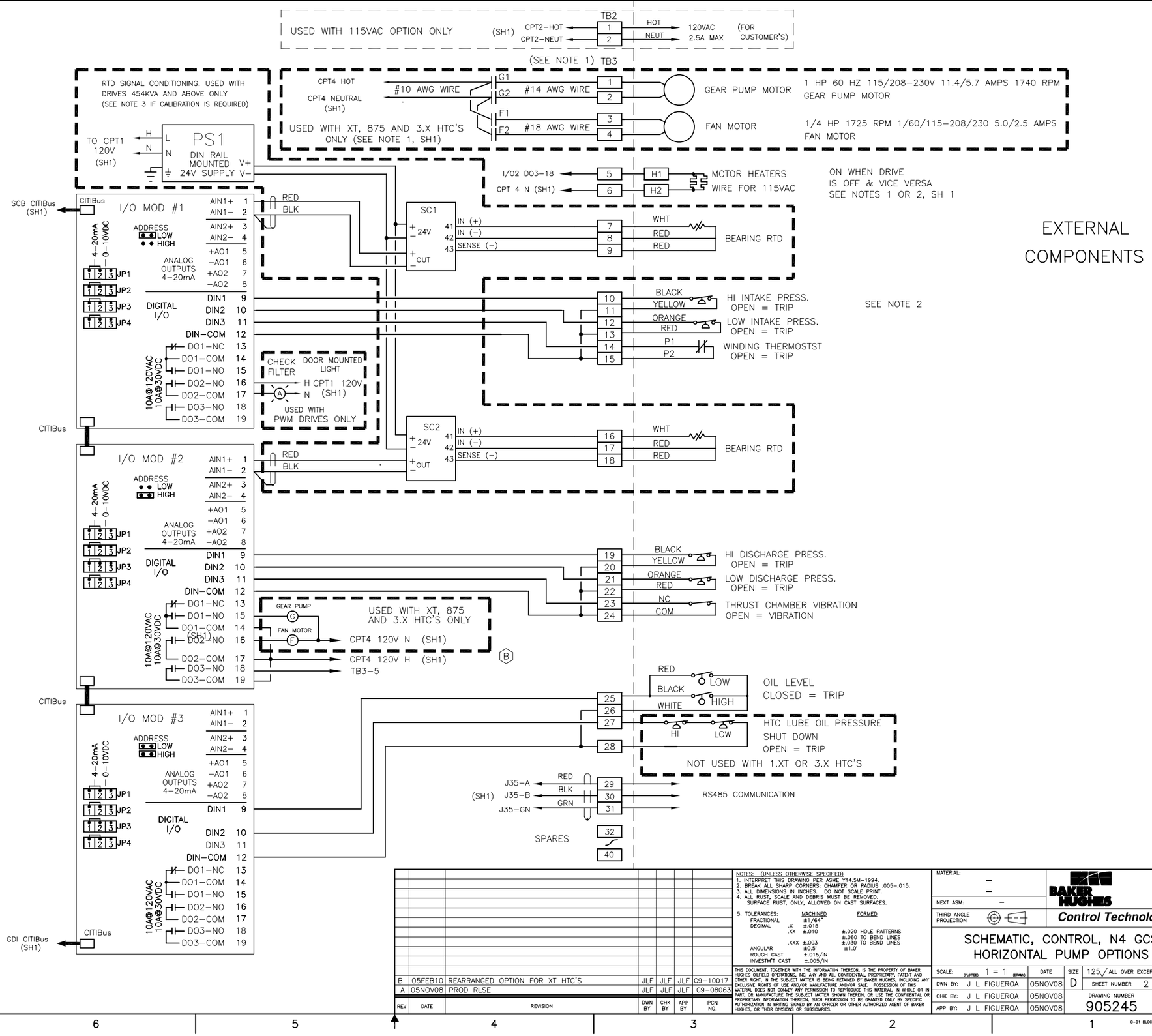
MATERIAL: –
NEXT ASM: –
THIRD ANGLE PROJECTION

BAKER HUGHES
Control Technologies

SCHEMATIC, CONTROL, N4 GCS HORIZONTAL PUMP OPTIONS

		DATE	SIZE	
SCALE: (PLOTTED) 1 = 1 (DRAWN)			D	125/ ALL OVER EXCEPT AS NOTED
DWN BY:	J L FIGUEROA	05NOV08		SHEET NUMBER 1 OF 2
CHK BY:	J L FIGUEROA	05NOV08		DRAWING NUMBER 905245 REV. C
APP BY:	J L FIGUEROA	05NOV08		

C–01 BLOCK REVISION LEVEL: E



NOTES:
1. KEEP ASSIGNED TERMINAL BLOCK NUMBERS. LEAVE BLOCKS AS SPARE WHEN NOT ALL OPTIONS ARE UTILIZED.
2. REFER TO INSTRUMENT RANGE CHART IN HPUMP O&M MANUAL FOR SET POINTS AND SET THE FOLLOWING 6 DIGITAL INPUTS THE SAME:
   - I/O1 DI1 - HI INTAKE PRESS.
   - I/O1 DI2 - LOW INTAKE PRESS.
   - I/O1 DI3 - WINDING TEMP.
   - I/O2 DI1 - HI DISCHARGE PRESS.
   - I//O2 DI3 - VIBRATION
   - I/O3 DI2 - HTC LUBE OIL PRESS.

ACTV ALM STATE	1
ALARM ENABLE	YES
LOCKOUT ENABLE	YES
BYPASS DELAY	0
SHUTDOWN DELAY	0
AUX RSTRT PARMS	NO

SET I/O3 DI1 - HTC OIL LEVEL
SAME AS ABOVE WITH THE EXCEPTION OF
ACTV ALM STATE 0

SET I/O2 DI2 - LOW DISCHARGE PRESS.
SAME AS ABOVE WITH THE EXCEPTION OF
BYPASS DELAY 3**

** SET LONG ENOUGH AFTER START TO ENSURE THAT THE DISCHARGE PRESSURE GOES ABOVE THE LOW PRESSURE SHUT OFF SETTING

3. SETUP THE SIGNALS FROM THE RTD's AS FOLLOWS:
   A. CONFIGURE THE RTD SIGNAL CONDITIONERS PER:
      a. INPUT: PT 100, 3-WIRE, α = 0.00385
      b. RANGE: -18 TO 300 DEG C
      c. OUTPUT: 4 - 20mA
      d. REVERSE OUT: OFF
      e. REMOTE CAL: OFF
   B. SET IO1A11 & IO2A11 AS FOLLOWS:

a. SPAN	300 DEG. C
b. Minimum Rding:	-18 (NEGATIVE 18)
c. INST TYPE	4-20mA

      d. Hi thid setup
         - HI THRESHOLD 170 DEG C
         - HI THLD ALARM ENB YES
         - HI THLD BYP DELAY & SD DLY: 0 SEC.
   C. WITH THE EXTERNAL RESISTORS SIMULATE RTD TEMPERATURE AND VERIFY THE OPERATION OF THE RTD CIRCUIT: WITH JUMPERS IN TB3 8-9 & 17-18, CONNECT ALTERNATELY THE RESISTORS BETWEEN TB3 7-9 & 16-18. AND VERIFY THE TEMPERATURE READINGS AS FOLLOWS:

RESISTANCE	TEMP READING (APROX)
110	25
165	170

IF CALIBRATION IS REQUIRED FOR THE RTD SIGNAL CONDITIONERS, CONSULT THE MANUAL (FOUND IN CENTRIVIEW AS P/N 902789).

REV	DATE	REVISION	DWN BY	CHK BY	APP BY	PCN NO.
B	05FEB10	REARRANGED OPTION FOR XT HTC'S	JLF	JLF	JLF	C9-10017
A	05NOV08	PROD RLSE	JLF	JLF	JLF	C9-08063

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5. TOLERANCES:

	MACHINED	FORMED
FRACTIONAL	±1/64"	
DECIMAL .X	±.015	
.XX	±.010	±.020 HOLE PATTERNS
		±.060 TO BEND LINES
.XXX	±.003	±.030 TO BEND LINES
ANGULAR	±0.5'	±1.0°
ROUGH CAST	±.015/IN	
INVESTMT CAST	±.005/IN	

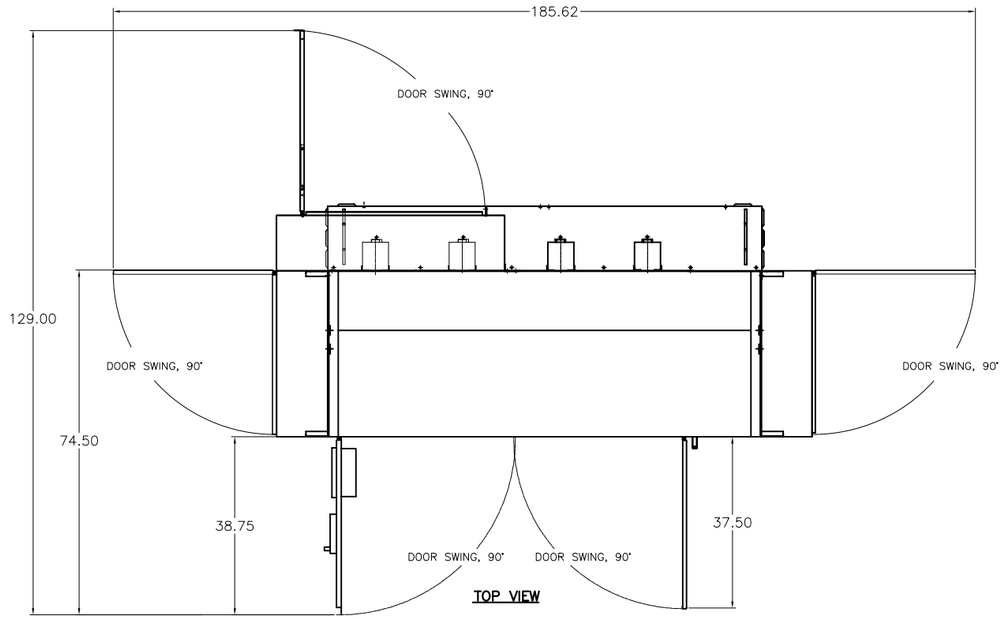
MATERIAL: –
NEXT ASM: –
THIRD ANGLE PROJECTION

BAKER HUGHES
Control Technologies

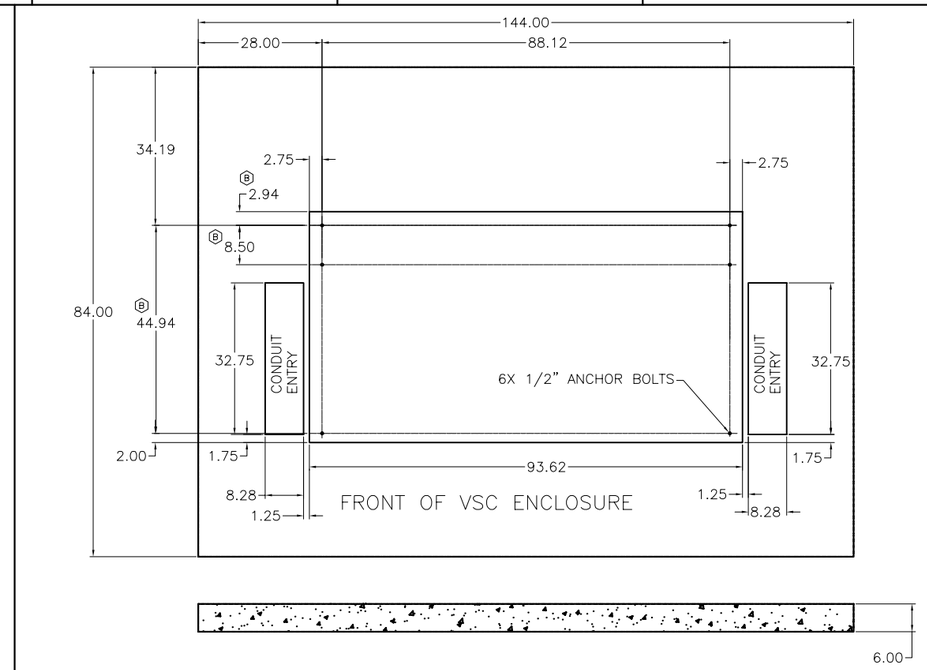
SCHEMATIC, CONTROL, N4 GCS HORIZONTAL PUMP OPTIONS

SCALE: (PLOTTED) 1 = 1 (DRAWN)	DATE	SIZE	125 ALL OVER EXCEPT AS NOTED		
DWN BY: J L FIGUEROA	05NOV08	D	SHEET NUMBER 2 OF 2		
CHK BY: J L FIGUEROA	05NOV08	DRAWING NUMBER 905245		REV. B	
APP BY: J L FIGUEROA	05NOV08				

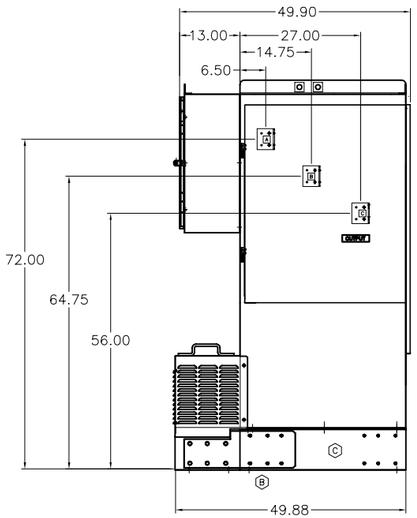
C-01 BLOCK REVISION LEVEL: E



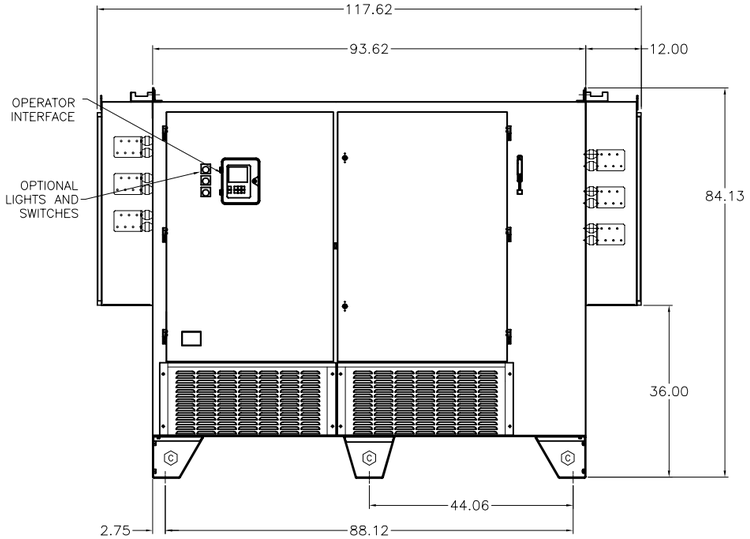
TOP VIEW



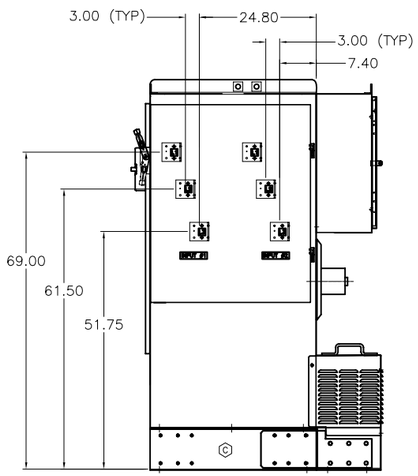
CONCRETE PAD LAYOUT



LEFT SIDE VIEW



FRONT VIEW



RIGHT SIDE VIEW

REV.	DATE	REVISION	DWN BY	CHK BY	APP BY	PCN NO.
C	23JAN08	ADDED NEW STAINLESS STEEL LEGS.	DON	WC	K.K.	C9-07178
B	07OCT03	REV FILTER TO SHORTER BASE DIM 44.94 WAS 19.25 & 31.88, ADD 8.50 DIM. SIDE VIEW 49.88 WAS 55.77,	DWC	D.I.	K.K.	17790
A	22SEP03	PROD RELEASE	DWC	D.I.	K.K.	17312
1	05SEP02	LIMITED RLSE	DWC	D.I.	K.K.	D05113

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. INTERPRET THIS DRAWING PER ANSI Y14.5M–1982
2. BREAK ALL SHARP CORNERS.
3. ALL DIMENSIONS IN INCHES. DO NOT SCALE PRINT.
4. ALL RUST, SCALE AND DEBRIS MUST BE REMOVED. SURFACE RUST, ONLY, ALLOWED ON CAST SURFACES.
5. TOLERANCES: MACHINED FORMED
FRACTIONAL ±1/64" ±.020 HOLE PATTERNS
DECIMAL .X ±.015 ±.060 TO BEND LINES
.XX ±.010 ±.030 TO BEND LINES
.XXX ±.003
ANGULAR ±0.5° ±1.0°
ROUGH CAST ±.015/IN
INVESTM'T CAST ±.005/IN

MATERIAL: –
–
NEXT ASM: –
THIRD ANGLE PROJECTION

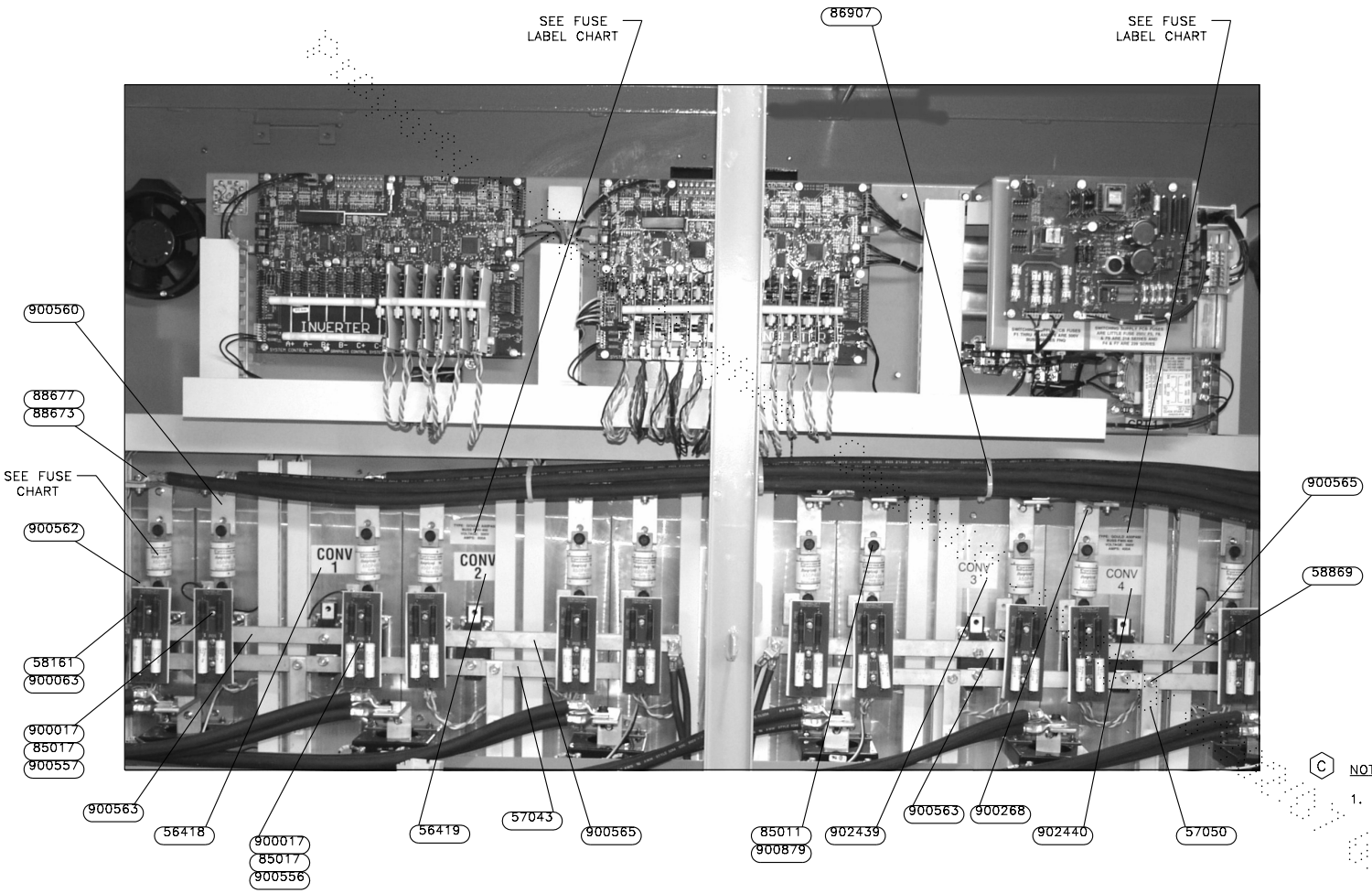
BAKER HUGHES Centrilift
Control Technologies

OUTLINE & ANCHOR DIMENSIONS 8000 SERIES, NEMA 4 GCS, WITH FILTER

SCALE: (PLOTTED) 1 = 8 (DRAWN)	DATE	SIZE	125 ALL OVER EXCEPT AS NOTED		
DWN BY: W CATES	22SEP03	D	SHEET NUMBER 1 OF 1		
CHK BY: D. INMAN	01OCT03	DRAWING NUMBER 902030		REV. C	
APP BY: K. KABRICH	01OCT03				

C-01 BLOCK REVISION LEVEL: B

PART NO.	DESCRIPTION
53793	LABEL, FUSE SPECIFICATIONS, 400A, 500V
53794	LABEL, FUSE SPECIFICATIONS, 300A, 500V
56418	LABEL, CONVERTER "1"
56419	LABEL, CONVERTER "2"
57043	BUS BAR, CONVERTER, NEGATIVE
57050	BUS BAR, INV/CONV, NEGATIVE LINK
58161	PCB S/A, SNUBBER
58869	SCREW, FSHH, M8x1.25-6g X 20mm LG
85011	WASHER, FLAT, .31"
85017	WASHER, LOCK, #8, INT STAR
86805	FUSE, 250A, 500V, FAST ACTING
86907	TIE, CABLE, .27" W X 13.50" LG, NYLON
88673	LUG FOR 4/0 CABLE, .31" STUD SIZE
88677	CABLE, 4/0, EPDM
88896	FUSE, 300A, 500V, FAST ACTING
88897	FUSE, 400A, 500V, FAST ACTING
900017	SCREW, HCS, M4x0.7-6g X 10mm LG
900063	INSULATOR, PAPER, SNUBBER PCB
900268	BOLT, FSHH, .250-20UNC X .50" LG
900556	STANDOFF, M-F, 8mm, HEX, SHORT
900557	STANDOFF, M-F, 8mm, HEX, LONG
900560	BUS BAR, INPUT
900562	BUS BAR, SCR TO FUSE
900563	BUS BAR, CONV, POSITIVE, LEFT SIDE
900565	BUS BAR, CONV, POSITIVE, RIGHT SIDE
900865	FUSE, 350A, 500V, FAST ACTING
900879	BOLT, FSHH, M8x1.25-6g X 25mm LG
900885	LABEL, FUSE SPECIFICATIONS, 250A, 500V
900947	LABEL, FUSE SPECIFICATIONS, 350A, 500V
902439	LABEL, CONVERTER "3"
902440	LABEL, CONVERTER "4"



C NOTE:

1. SEE 901196 FOR THE ASSEMBLY OF THE INVERTER SECTION.

FUSE & INPUT FUSE LABEL CHART

VSC MODEL	FUSE RATING	FUSE P/N	LABEL P/N
8600	250A, 500V	86805	900885
8700	300A, 500V	88896	53794
8800	350A, 500V	900865	900947
8900	400A, 500V	88897	53793

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. INTERPRET THIS DRAWING PER ANSI Y14.5M-1982
2. BREAK ALL SHARP CORNERS.
3. ALL DIMENSIONS IN INCHES. DO NOT SCALE PRINT.
4. ALL RUST, SCALE AND DEBRIS MUST BE REMOVED. SURFACE RUST, ONLY, ALLOWED ON CAST SURFACES.

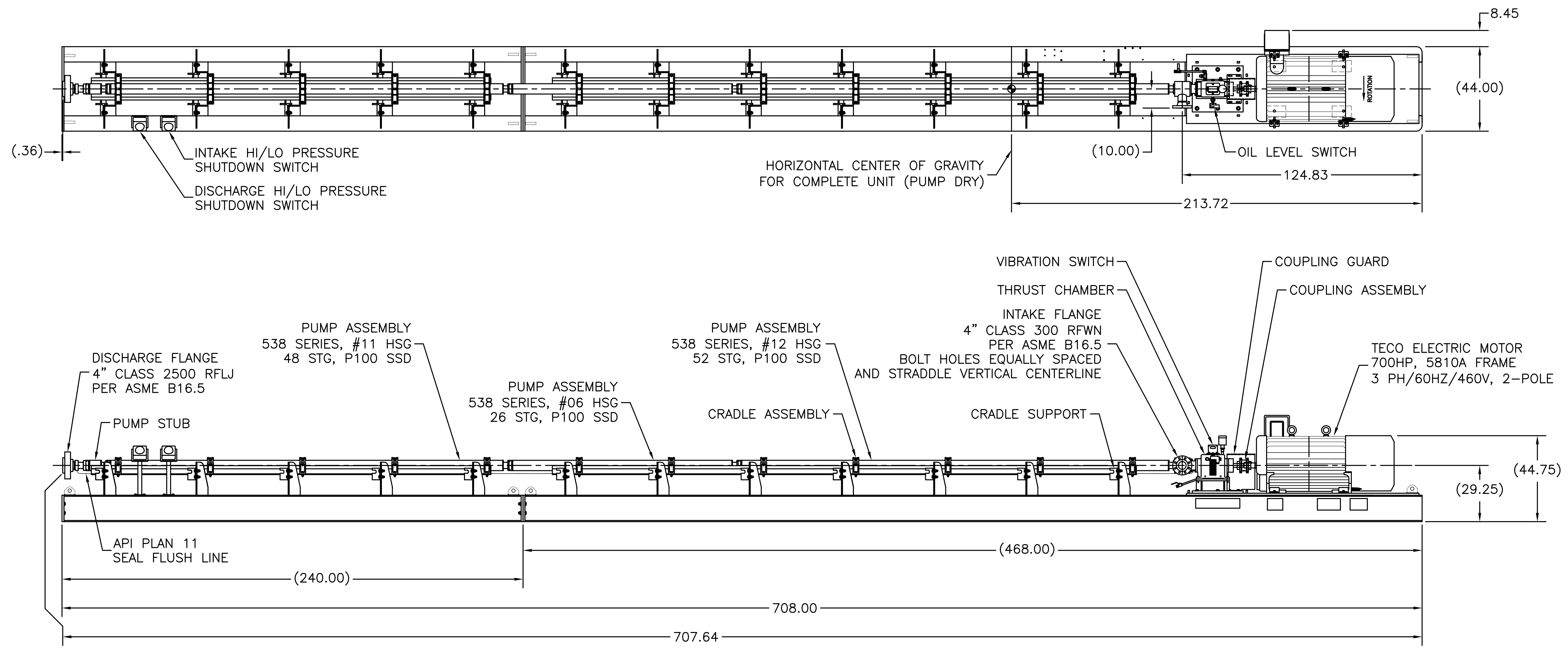
5. TOLERANCES: MACHINED FORMED
FRACTIONAL ±1/64"
DECIMAL .X ±.015
.XX ±.010 ±.020 HOLE PATTERNS
±.060 TO BEND LINES
.XXX ±.003 ±.030 TO BEND LINES
ANGULAR ±0.5° ±1.0°
ROUGH CAST ±.015/IN
INVEST'T CAST ±.005/IN

MATERIAL:
NEXT ASM:
THIRD ANGLE PROJECTION

BAKER HUGHES Centrilift
Control Technologies

ASSEMBLY, 24 PULSE CONVERTER, 8000 N4, 24P, GCS

SCALE: 1 = 1	DATE	SIZE	125 ALL OVER EXCEPT AS NOTED	
DWN BY: DW CATES	16OCT03	D	SHEET NUMBER 3 OF 9	
CHK BY: D. INMAN	16OCT03	DRAWING NUMBER 902571		REV. C
APP BY: K. KABRICH	16OCT03			



NOTES:

1. INTAKE AND DISCHARGE PIPING CONNECTIONS MUST BE FIELD INSTALLED & ADEQUATELY SUPPORTED TO PREVENT INDUCED PIPING LOADS ON TO THE PUMP SYSTEM.
2. ALL DIMENSIONS SHOWN ARE INCHES.
   TOLERANCE FOR DIMENSIONS SHOWN ARE ±.25".
   DIMENSIONS IN PARENTHESES () ARE FOR REFERENCE ONLY.
3. TOTAL SKID WEIGHT WITH MOTOR & PUMP=21596 LBS APROX.
   MOTOR WEIGHT=6600 LBS, APPROX
   PUMP WEIGHT=2175 LBS, APPROX
4. INTAKE POSITION SHOWN FOR CLARIFICATION PURPOSES ONLY. INTAKE CAN BE ORIENTED IN MULTIPLE DIRECTIONS.
5. REFER TO EDA-3890 FOR FOUNDATION DETAILS.
6. TANDEM (MULTIPLE) SKIDS SHOULD NEVER BE LIFTED, TRANSPORTED OR OTHERWISE MOVED WHILE FASTENED TOGETHER.
   ALWAYS REMOVE INTERCONNECTING BOLTING BETWEEN SKIDS PRIOR TO MOVING ASSEMBLIES TO PREVENT DAMAGE TO EQUIPMENT.
7. ALL INSTRUMENTS & MOTOR TO BE FIELD WIRED.
   REFER TO IOM'S FOR CONNECTIONS.

REV	DATE	REVISION	DWN BY	CHK BY	APP BY	PCN NO.
A	11MAR10	PRODUCTION RELEASE	JBH	MDT	MSK	SE31040

Baker Hughes Centrilift
Centrilift Products

INSTALLATION DRAWING, 1.XE HTC SERIES 3000 SKID, 59'-0" LONG

SCALE: 1=18	DATE	SIZE F	SHEET NUMBER 1 OF 1
DWN BY: JERRY HENRY	11MAR10		
CHK BY: MILES TORREGANO	15MAR10	DRAWING NUMBER	REV.
APP BY: MATT KILKER	15MAR10	315774	A

AutographPC®

Centrilift - A Baker Hughes company

HPump

3030 NW Expressway, Suite 300, Oklahoma City, OK 73112

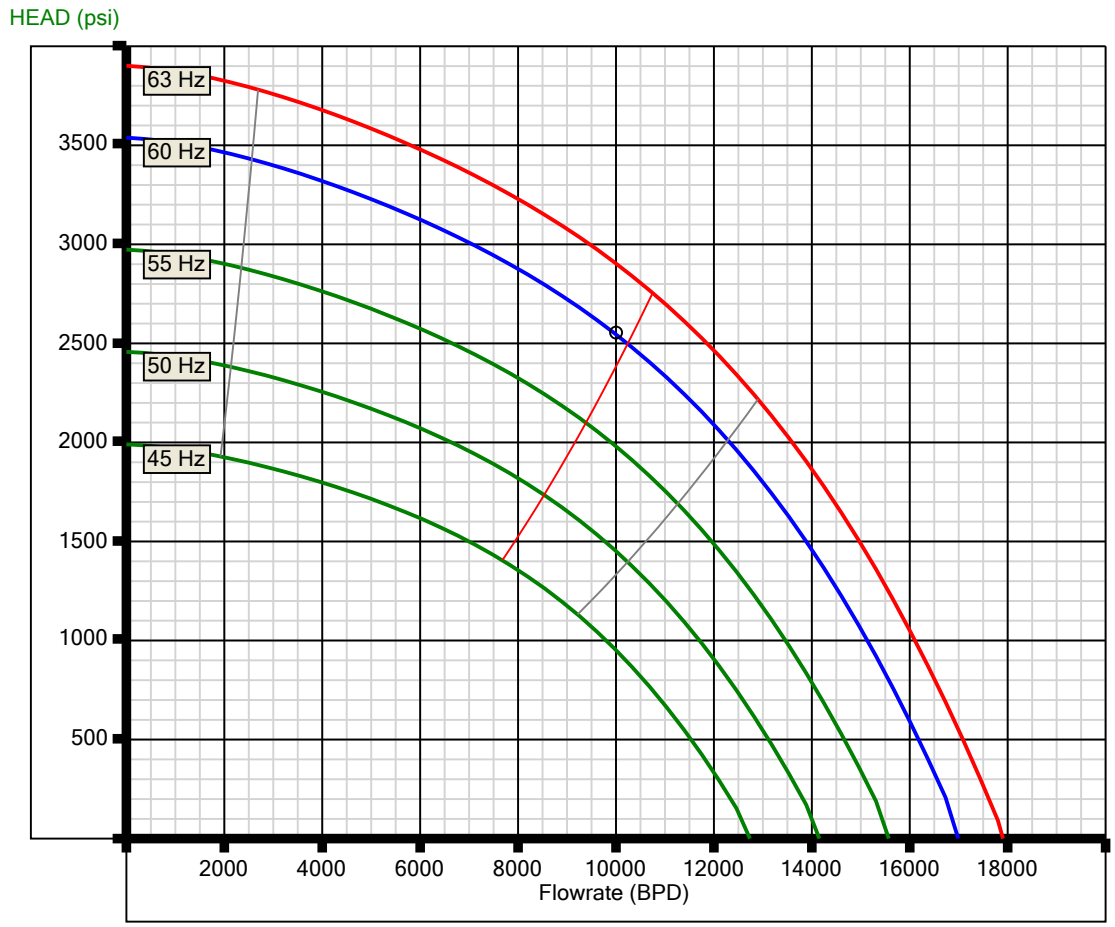
Project: Fayetteville SWD
Customer: Chesapeake
Well: SRE 8-12 1-17 SWD
Engineer: Joe Jones

Pump: 127-538P100LSSSD
ThChmbr: 1.XE HTC
Motor: Teco TEFC 700 HP 460 V 728 A
Controller: VSD 8600-VT 624kVA/ 480V/ 750A

NOTE: Motor ratings at 60Hz

Comments:
Parallel Operation at 60 hz

127-538P100LSSSD



AutographPC® V7.7 File:Chesapeake Cotton Hill 8-12 1-17 SWD 3-1-10.apcx

AutographPC®

Centrilift - A Baker Hughes company

HPump

3030 NW Expressway, Suite 300, Oklahoma City, OK 73112

Project:	Fayetteville SWD	**Pump:**	127-538P100LSSSD
Customer:	Chesapeake	**ThChmbr:**	1.XE HTC
Well:	SRE 8-12 1-17 SWD	**Motor:**	Teco TEFC 700 HP 460 V 728 A
Engineer:	Joe Jones	**Controller:**	VSD 8600-VT 624kVA/ 480V/ 750A

NOTE: Motor ratings at 60Hz

Comments:
Parallel Operation at 60 hz

Operating Parameters / Selection:

Design Point:

Desired flow (total)	= 10000 BPD
Frequency	= 60.1 Hz
TDH	= 5786 FT

Pump Selection:	Intake	Discharge	Pump Selected:
Pressure	= 250 psi	2805 psi	CENTURION 127-538P100LSSSD
Flowrate	= 10000 BPD	10000 BPD	Pshaft RPM = 3588
Specific Gravity	= 1.02 rel-H2O	1.02 rel-H2O	Shft HP @ 60.1 Hz = 617
Viscosity	= 1.0Cp	1.0Cp	Shaft load =(Std 75%) / (HS 48%)
			Required Motor HP at 60.0 Hz = 621

Parallel Pumps - 24k bpd @ 3300 psid - 900 HP Motor - 1000 kva VSD

Thrust Chamber Selection:

Type	= 1.XE HTC
No sand present	
Pump uses floater-type stages	
Thrust Load	= 47.1 %
ShaftHPcap	= 801 HP

Surface Motor Selection

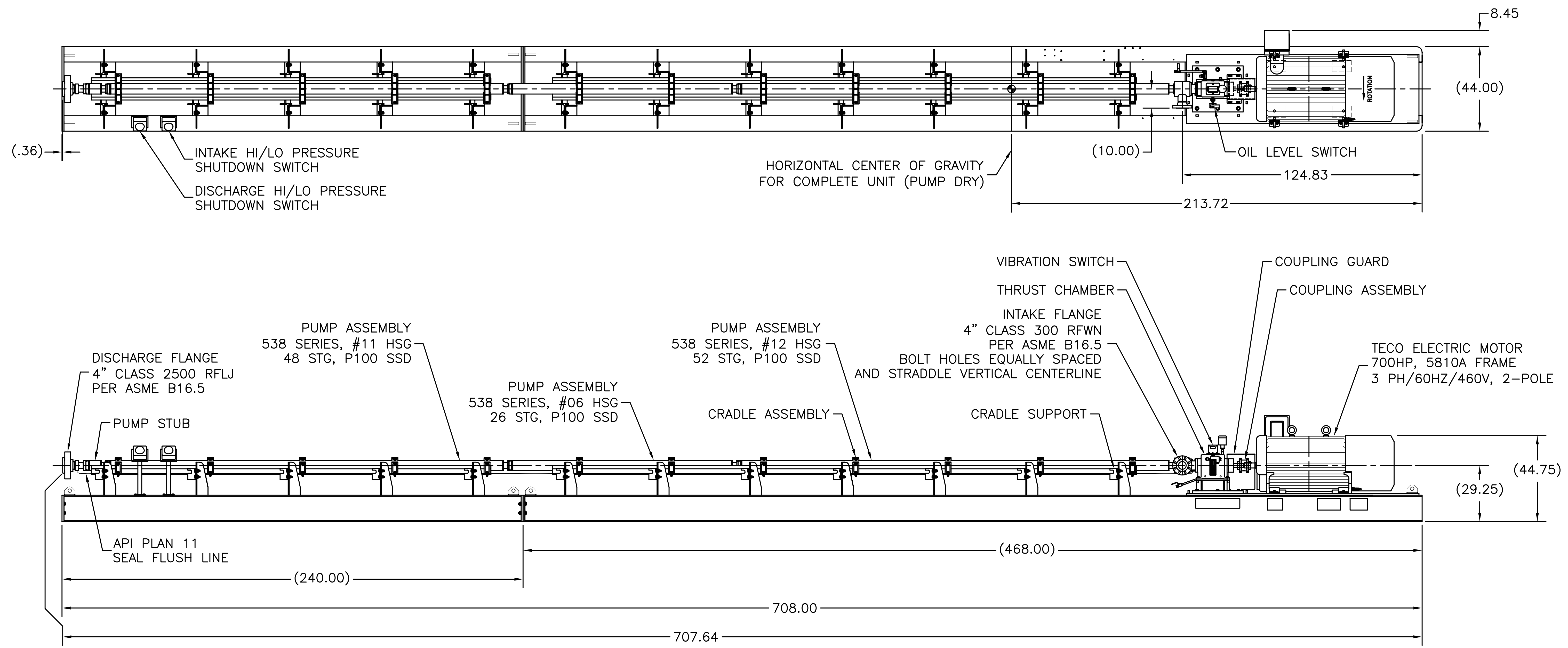
Motor Selected	=Teco TEFC 700 HP 460 V 728 A
Terminal Voltage	=460.7 V
Motor Current	=647.8 A
Load acc to N.P.	=88.7 %
Max Elevation	= 3300ft
Max Amb Temp	=104°F
Power Type	=UNFILT
Frame	=5010SY

No comments

Controller Selection:

Input kVA	= 532.6kVA	Voltage Input	= 480V
System kW	= 511.3kW	Max Well Head Volts	= 461V
Max Ctrl Current	= 621.8A	Max Frequency	= 60.1Hz (7.99V/Hz)
Power Cost/kWH	= 0.05$/kWH	Step-up Trafo	= 0.96 ratio
Total Power Cost	= $18407/month	Selected: VSD 8600-VT 624kVA/ 480V/ 750A	

No comments AutographPC® V7.7 File:Chesapeake Cotton Hill 8-12 1-17 SWD 3-1-10.apcx



NOTES:

1. INTAKE AND DISCHARGE PIPING CONNECTIONS MUST BE FIELD INSTALLED & ADEQUATELY SUPPORTED TO PREVENT INDUCED PIPING LOADS ON TO THE PUMP SYSTEM.

2. ALL DIMENSIONS SHOWN ARE INCHES.
TOLERANCE FOR DIMENSIONS SHOWN ARE ±.25".
DIMENSIONS IN PARENTHESES () ARE FOR REFERENCE ONLY.

3. TOTAL SKID WEIGHT WITH MOTOR & PUMP=21596 LBS APROX.
MOTOR WEIGHT=6600 LBS, APPROX
PUMP WEIGHT=2175 LBS, APPROX

4. INTAKE POSITION SHOWN FOR CLARIFICATION PURPOSES ONLY.
INTAKE CAN BE ORIENTED IN MULTIPLE DIRECTIONS.

5. REFER TO EDA-3890 FOR FOUNDATION DETAILS.

6. TANDEM (MULTIPLE) SKIDS SHOULD NEVER BE LIFTED, TRANSPORTED OR OTHERWISE MOVED WHILE FASTENED TOGETHER.
ALWAYS REMOVE INTERCONNECTING BOLTING BETWEEN SKIDS PRIOR TO MOVING ASSEMBLIES TO PREVENT DAMAGE TO EQUIPMENT.

7. ALL INSTRUMENTS & MOTOR TO BE FIELD WIRED.
REFER TO IOM'S FOR CONNECTIONS.

REV	DATE	REVISION	DWN BY	CHK BY	APP BY	PCN NO.
A	11MAR10	PRODUCTION RELEASE	JBH	MDT	MSK	SE31040

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. INTERPRET THIS DRAWING PER ANSI Y14.5M-1982
2. BREAK ALL SHARP CORNERS: CHAMFER OR RADIUS .005-.015.
3. ALL DIMENSIONS IN INCHES. DO NOT SCALE PRINT.
4. ALL RUST, SCALE AND DEBRIS MUST BE REMOVED. SURFACE RUST, ONLY, ALLOWED ON CAST SURFACES.
5. TOLERANCES:

		MACHINED	FORMED
FRACTIONAL		±1/64"	
DECIMAL	.X	±.015	
	.XX	±.010	±.020 HOLE PATTERNS ±.060 TO BEND LINES
	.XXX	±.003	±.030 TO BEND LINES
ANGULAR		±0.5°	±1.0°
ROUGH CAST		±.015/IN	
INVESTM'T CAST		±.005/IN	

MATERIAL:
NEXT ASM:
THIRD ANGLE PROJECTION

BAKER HUGHES Centrilift
Centrilift Products

INSTALLATION DRAWING, 1.XE HTC
SERIES 3000 SKID, 59'-0" LONG

SCALE: (PLOTTED) 1 =18 (DRAWN)	DATE	SIZE	✓ ALL OVER EXCEPT AS NOTED	
DWN BY: JERRY HENRY	11MAR10	F	SHEET NUMBER 1 OF 1	
CHK BY: MILES TORREGANO	15MAR10		DRAWING NUMBER	REV.
APP BY: MATT KILKER	15MAR10		315774	A

C-F1 BLOCK REVISION LEVEL: D

TECO Westinghouse

OPERATION

&

MAINTENANCE

MANUAL

FOR

THREE PHASE

INDUCTION

MOTORS

TECO-Westinghouse Motor Company
5100 North IH-35
Round Rock, Tx. 78681

INDEX PAGE

1. INTRODUCTION

This and the following instruction address the more common situations encountered in motor installation, operation and maintenance. For the TWMC motor warranty to be and to remain in effect, the motor must be installed and operated in strict accordance with the outline drawing, motor nameplates and these instructions and must not be altered or modified in any unauthorized manner.

During the installation and operation of motors in heavy industrial applications there is a danger of live electrical parts and rotating parts. Therefore to prevent injury and/or damage the basic planning work for installation, transportation, assembly, operation, etc... needs to be done and checked by authorized and competent personnel only.

Since these instructions cannot cover every eventuality of installation, operation and maintenance, the following points should be considered and checked.

- The technical data and information on permissible use such as assembly, connection, ambient and operating conditions given in the related catalogue, operating instructions, nameplates and other production documentation.
- The general erection and safety regulations.
- The local and plant-specific specifications and requirements.
- The proper use of transport, lifting devices and tools.
- The use of personal protective equipment.

Following indications should be observed when reading these instructions.

Safety instructions are marked as follows:

Warning of electric hazards for personnel.

Warning of dangers for personnel.

ATTENTION!
Warning of damage for the motor or installation.

2. ACCEPTING, INSPECTION, STORAGE, TRANSPORTATION

Inspection upon receipt
Check to following points upon receipt:

- Are the nameplate ratings identical with what you ordered?
- Are dimensions and color in compliance with your specifications?
- Are the nameplate ratings for space heater, thermal protector, temperature detector, etc. identical with what you ordered?
- Is there any damage?
- Are all accessories and accompanying instruction manuals in good order?
- Please ensure that the arrow head indicator really indicates direction of rotation.
- If there are any specific requirements, please ensure they are in conformity with your specifications.

2.1 Storage
When motors are not in operation, the following precautionary measures should be undertaken to assure best performance.

2.2 Place
(a) High and dry, well ventilated without direct sun, dust or corrosive gas.
(b) Not located near to a boiler or freezer.
(c) Entirely free form vibration and easy for movements.
(d) Motors should be put on pallets to prevent moisture.

2.3 Moisture prevention
Since moisture can be very detrimental to electrical components, the motor temperature should be maintained about 3ºC above the dew point temperature by providing either external or internal heat. If the motor is equipped with space heaters, they should be energized at the voltage shown by the space heater nameplate attached to the motor. Incandescent light bulbs can be placed within the motor to provide heat. However, if used, they must not be allowed to come in contact with any parts of the motor because of the concentrated hot spot that could result.

2.4
Even during storage, the insulation resistance should be kept above the specified values.
(a) For measurement of insulation resistance and acceptable standard values, please refer to measures stated in 4.1.2 “Measurement of insulation resistance”.
(b) Insulation resistance test should be performed once every three months.

2.5

If the motor is not in operation for a long period (one week and above) after installation or has been in operation but stopped for a period of time, the following precautions must be taken.

(a) Protect the motor as measures stated in 2.3.
(b) Insulation resistance test should be performed as stated in 2.4.

2.6 Bearing protection

(a) If the motor has been provided with a shaft shipping brace to prevent shaft movement during transit, it must be removed before operating the motor. It is very important that this brace be re-installed exactly as it was originally, before the motor is moved form storage or any time when the motor is being transported. This prevents axial rotor movement that might damage the bearings.
(b) Motors equipped with sleeve bearings are shipped from the factory with the bearing oil reservoirs drained. In storage, the oil reservoirs should be properly filled to the center of the oil level gauge with a good grade of rust inhibiting oil. To keep the bearing journals well oiled and to prevent rusting, the motor shaft should be rotated several revolutions about every month ensuring the shaft does not come to rest in its original position. While the shaft is rotating, it should be pushed to both extremes of the endplay.
(c) Motors with anti-friction bearings are properly lubricated with the correct grade of grease at the factory and no further greasing is required in storage. The shaft should be rotated several revolutions about every month to maintain proper distribution of the grease within the bearings.
(d) Tilt-pad bearings are a type of sleeve bearing used in special design applications. Due to the nature of this bearing, a loose oil ring for delivering lubricant cannot be provided. Therefore, during the storage internal, oil must be periodically manually introduced into the pads and housing to prevent the occurrence of oxidation of the precision machined components.
    (1) Remove the pipe plug from the bearing cap located above the tilt-bearing shell.
    (2) Pour in approximately one cup of oil every month and rotate the shaft a few revolutions about every two (2) weeks.
    (3) For long periods of storage, the oil that accumulates in the housing should be removed.

ATTENTION!
Care should be taken to keep parts such as fitting surfaces, key, shaft extension and axial central hole from any collision with foreign matter. Grease should also be generously applied to prevent rusting.

2.7 Transportation

To keep the rotating parts of motors from moving, thus preventing damage and scratching during transportation, they should be held securely with a locking device. Remove all transit clamps before operating the motor. It is very important that this device be reinstalled exactly as it was originally, before the motor is moved from storage or any time when the motor is being transported. The vertical mounting type motors should be transported in the vertical position.

Do not use the hoisting hook/eyebolts to lift more that the motor itself. They are designed to support the motor only. Make sure the hoisting hook is correctly attached to the eyebolt(s)/lug(s) are fully screwed in before hoisting. Also note such parts as fan cover, ventilation box, bracket, slip-ring, etc. may have their own hoisting lugs which can only carry their own weight. Nothing extra should be attached while hoisting.
Do not twist the steel wires and make sure the eyebolts have been firmly screwed and the sling angle is correct.

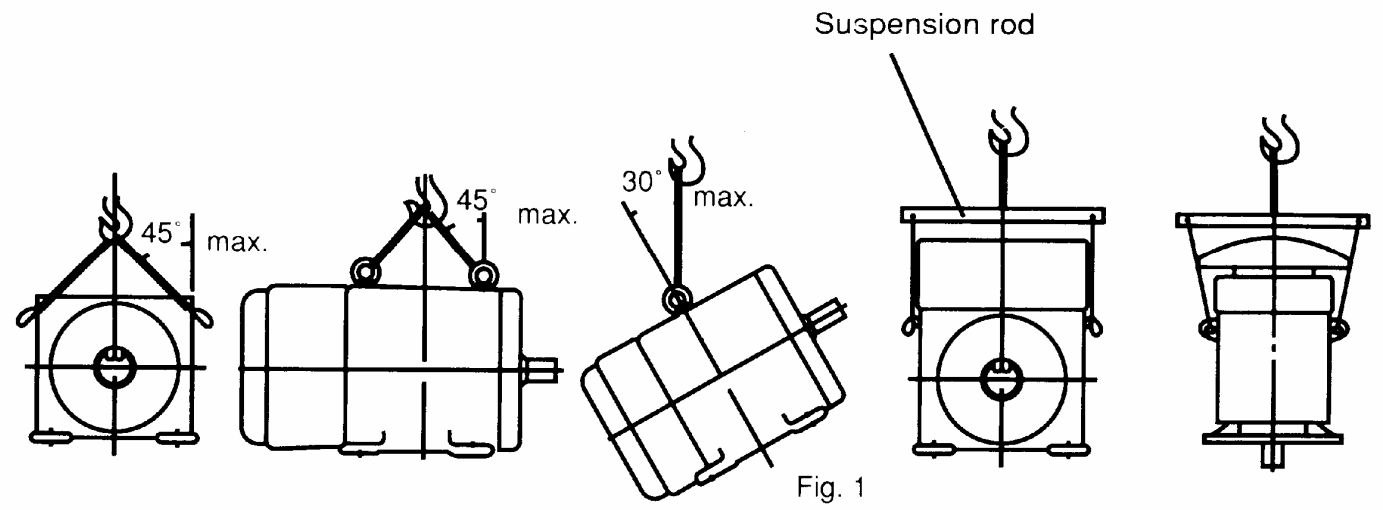


Fig. 1

3 INSTALLATION

Site and environment for motor installation

3.1.1

Standard environment and site conditions for the installation of motors are usually set as follows:

(a) Ambient temperature: -10~40ºC
(b) Humidity: Relative humidity below 90%RH for totally enclosed types, and below 80%RH for semi-enclosed types.
(c) Elevation: below 1000 meters or 3300 feet.
(d) Harmful gases, liquids, dusts, high moisture should be absent.
(e) Foundations should be strong and free of vibration.

If there are any special environmental conditions, please inform TWMC prior o ordering.

3.1.2 Ventilation and space

(a) Installation area should be well ventilated.
(b) The installation space should be large enough to facilitate heat dissipation and maintenance.

3.2 Foundation

3.2.1

Use rigid and solid sole plate or common bed as foundation.
For best motor performance, it is advisable to use a sole plate or common bed, particularly when using a shaft coupling.

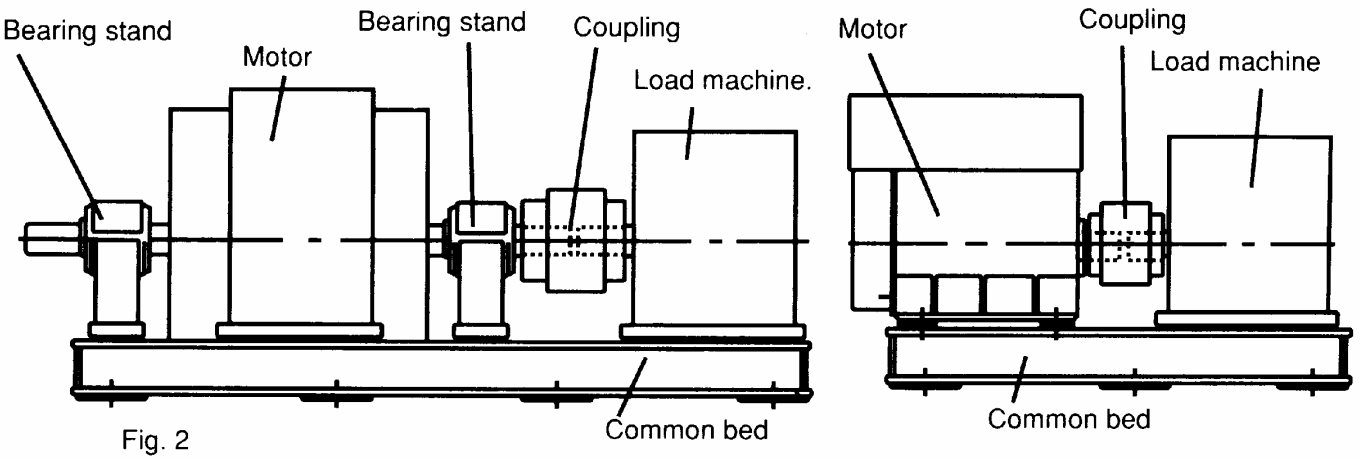


Fig. 2

3.2.2 Installation

(a) Select an appropriate foundation surface for the sole plate or common bed, which will be, considered the ultimate level.
(b) Align the position of the common bed with reference to that level.
(c) Align the level accuracy at least at four points such as bearing mounting, shaft extension etc. The accuracy should be within 0.04mm or .0015 inches
(d) Sole plate or common bed should be embedded in concrete foundation as illustrated in Fig. 3. Stiff pads should also be installed beneath the wedges, which are welded together at various spots about 400-500mm (15.75-19.70 inches) apart etc., to enable the foundation to carry evenly the weight of the whole motor.
(e) The base should be sturdy and rigid to keep it flat and level.
(f) Make sure the mortar and concrete are completely dry, and the precision of the level is acceptable, and then set the motor on the mounting foundation.
(g) Accurately install shaft couplings, belt sheaves etc., then weld the wedges solid to prevent untoward change in position.

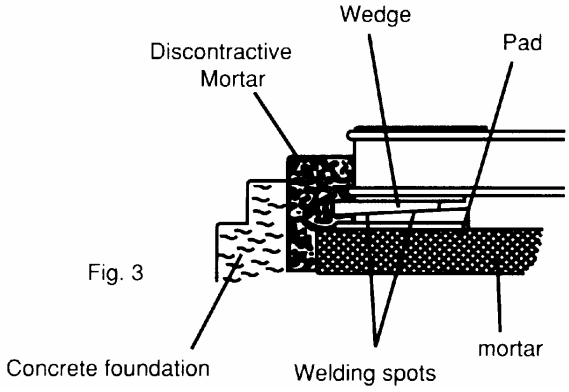


Fig. 3

3.2.3 The foundation of vertical induction motors: (Also the foundation of pump)

(a) Foundation of motor/pump must be rigid and secure to provide adequate support. There must be no vibration, twisting, misalignment etc. due to inadequate foundations.
(b) A massive concrete foundation is preferred in order to minimize vibration. Rigidity and stability are enhanced by prop plate and foundation bolt. As shown in Fig. 4.

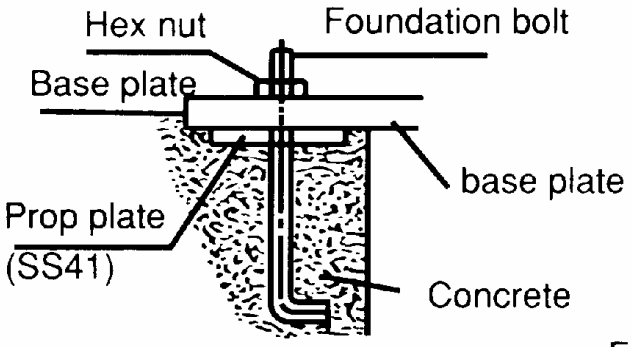


Fig. 4

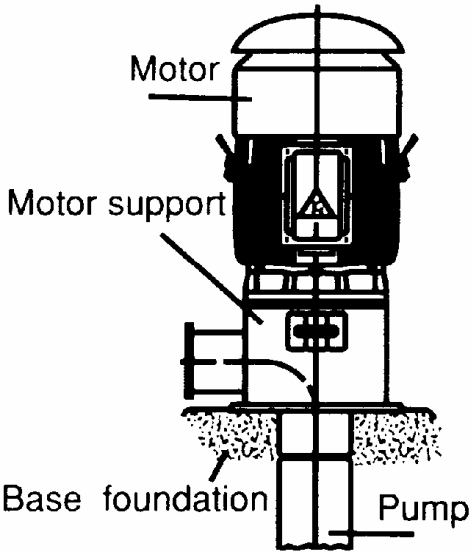


Fig. 5

3.2.4 Installation of vertical motors:

(a) All mounting surfaces must be clean and level.
(b) Foundation must be leveled at least at 4 points and guaranteed to be below 0.04mm (.0015 in.) flat and level.
(c) Make sure the mortar and concrete are completely dry, and the precision of the level is acceptable, and then set the motor on the mounting foundation.
(d) Accurately install shaft couplings.

3.3 Installation of shaft coupling

ATTENTION!
Motors must always be accurately aligned, and this applies especially where they are directly coupled.
Incorrect alignment can lead to bearing failure, vibration and even shaft fracture. As soon as bearing failure or vibration is detected, the alignment should be checked.

3.3.1

Field application of a coupling to the motor shaft should follow the procedures recommended by the coupling manufacturer. The motor shaft extension must not be subjected to either extreme heat or cold during coupling installation.

ATTENTION!
Basically, the coupling should be heated and pushed onto the shaft extension with slight axial force. Do not hammer coupling to prevent bearing damage.

3.3.2

Although the sleeve bearings are equipped with thrust faces, these are intended only to provide momentary axial restraint of rotor movement either during start-up or when operating the motor disconnected from the driven equipment. They must not be operated under a constant thrust load unless they were originally designed for this condition.

Motors with either sleeve or anti-friction bearings are suitable for connection to the driven load through a flexible coupling. Coupling solidly to the load is not acceptable. With sleeve bearings, the flexible coupling should be of the limited end float type to prevent the possibility of any end thrust from load being transmitted to the motor bearings, which could cause bearing damage. The recommended limits of end float are as follows:

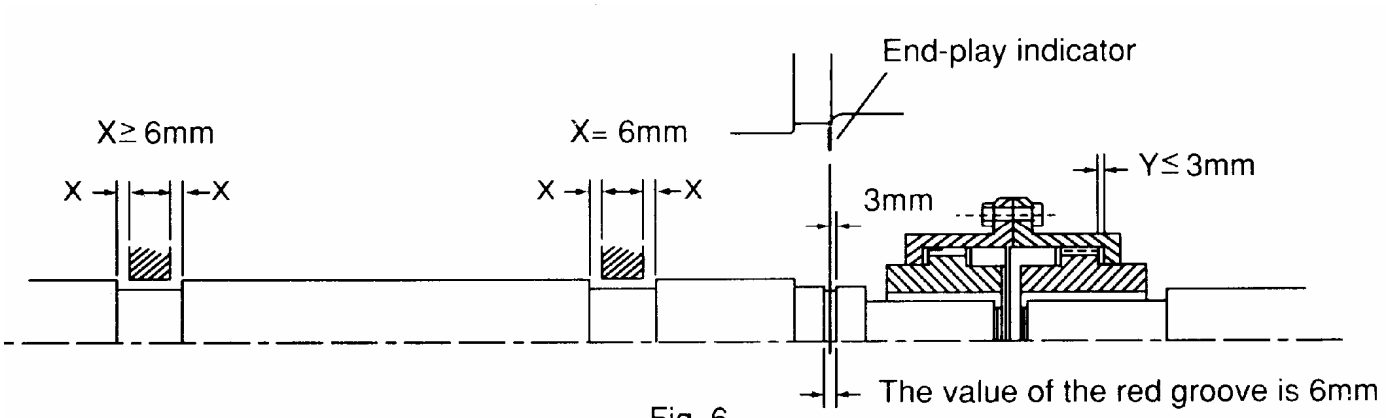


Fig. 6

(a) When the motor is in operation after installation, be sure that the end-play indicator is within the 6mm (.236 in.) of the groove on the shaft or aligned to the shaft shoulder immediately outboard of the drive-end bearing to assure there is low friction between shaft and bearing.
(b) Unless otherwise specified, the designed end-play value X of the groove for TWMC motors in general is within 6mm (.236 in.) as illustrated in Fig. 6. In essence, the endplay indicator is adjusted to point at the center of the groove or the drive-end shaft shoulder; thus X equals to 6±1mm or so, and the endplay value (Y) of the couplings should equal or be smaller than 3mm (.118 in.).
(c) If the desired value Y is grater than 3mmm (.118 in.) caused for instance by a thrust load and/or load machine with large end-play, please inform TWMC prior to entering an order.

3.3.3
In aligning the motor (and rotor) axially with the driven equipment, consideration should be given not only to the endplay indicator position but also to axial shaft expansion and increase in shaft centerline height due to thermal effects. In general, the axial shaft growth for motors can be disregarded since neither bearing is fixed and any shaft growth due to temperature increase will produce an elongation away from the coupling.

Shaft height growth (change in shaft centerline elevation) for TEFC machines can be calculated as follows:

Δ=(0.0005”) x (motor foot to shaft £ dimension)

For non-TEFC machines, divide the number by 2.

3.3.4
It is desirable, in normal operation that the motor operates on its magnetic center, so that no axial force is exerted on the coupling.

The motor shaft and the driven shaft should be aligned within the following tolerances in both angular and parallel alignment:

Unit: mm

TIR	Range of rotating speed	Solid coupling	Flexible coupling
C	2500 rpm and above	0.03	0.03
	Below 2500 rpm	0.04	0.05
A	2500 rpm and above	0.03	0.03
	Below 2500 rpm	0.03	0.04

Angular misalignment is the amount by which the centerlines of driver and driven shafts are skewed. It can be measured using a dial indicator set up as shown in Fig. 7. The couplings are rotated together through 360 degrees so that the indicator does not measure runout of the coupling hub face. The shafts should be forced against either the in or out extreme of their end float while being rotated.

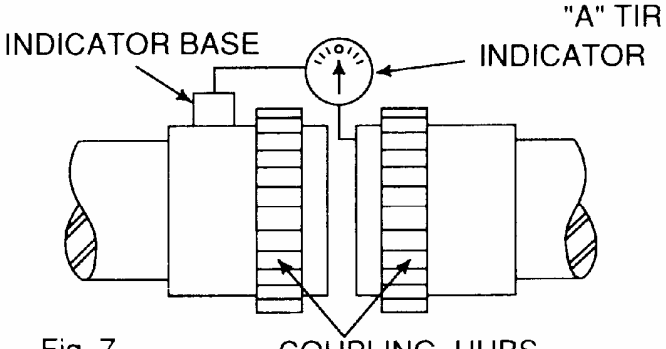


Fig. 7

TIR=Total indicator reading (by dial indicator)

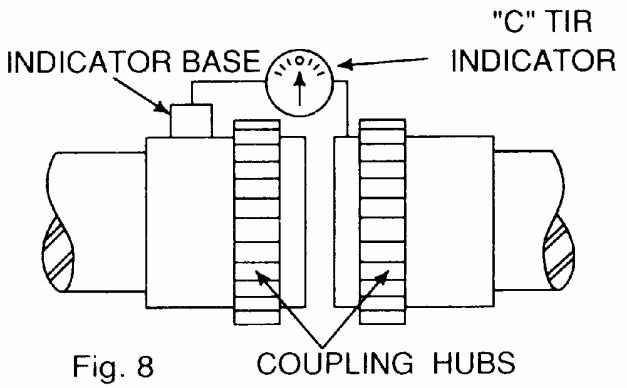


Fig. 8

Parallel misalignment is the amount by which the centerlines of the driver and driven shafts are out of parallel. It can be measured using a dial indicator set up as shown in Fig. 8. Again, the couplings are rotated together through 360 degrees so that the indicator does not measure runout of the coupling hub outside diameter.

3.3.5

After the motor has been properly aligned with the driven equipment and the hold-down bolts have been installed and tightened, for motors with fabricated frames, at least two dowel pins should be installed in two diagonally opposite motor feet.

3.3.6 Installation of shaft coupling: (Vertical hollow shaft motor only)

Bolted Coupling as shown in Fig. 9

(a) Bearings are provided to absorb some upward shaft thrust when the coupling is fitted.
(b) The coupling is fastened with bolts.
(c) This coupling type is not auto-release type.

Note: Standard high thrust motors can absorb momentary up-thrust load up to 30% of the standard down thrust load. If the up-thrust is long in duration (over 10 Seconds) and/or exceeds 30% of the standard high thrust rating, special design arrangements are required and standard motor is not suitable.

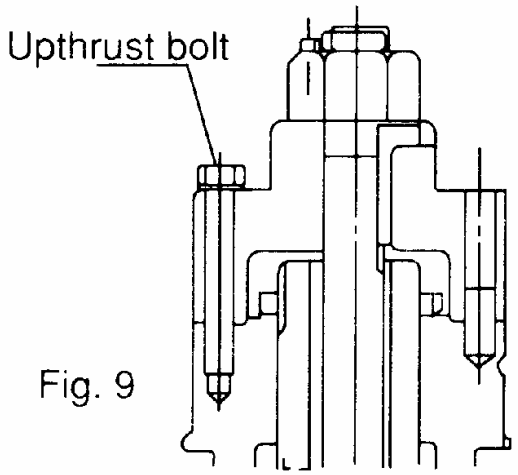


Fig. 9

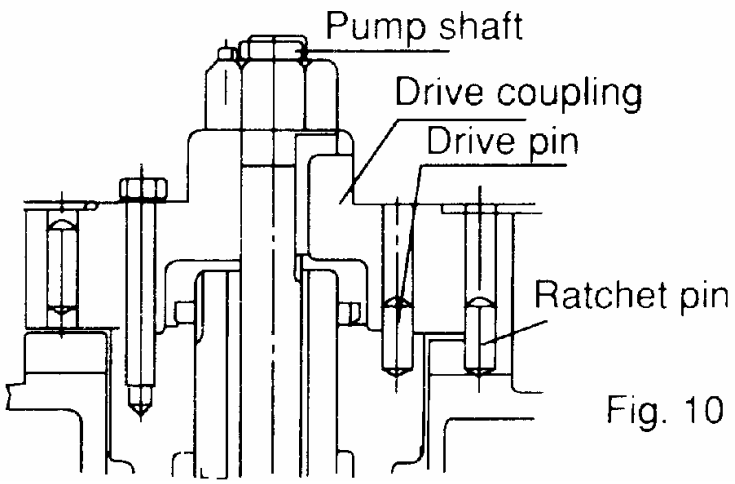


Fig. 10

3.3.7 Non-reverse ratchet/coupling, as Fig. 10 (If necessary)

The non-reverse coupling is also a bolted type and,

(a) It prevents the pump and motor from rotating in the reverse direction.
(b) It also prevents damage form over speeding and damage to pump shaft and bearings.
(c) The ratchet pins are lifted by the ratchet teeth and are held clear by centrifugal force and friction as the motor comes up to speed.
(d) When power is removed, speed decreases, and the pins fall. At the instant of reversal, a pin will catch in a ratchet tooth and prevent backward rotation.
(e) When installing the non-reverse coupling, do not use lubricant. Lubricant will interfere with proper operation. The top half of the coupling should seat solidly on the lower half and the pins should touch the bottom of the pockets between the teeth in the plate.
(f) As with the bolted coupling, the up-thrust capabilities are 30% of the standard high thrust rating for down thrust.

ATTENTION!
Do not apply non-reverse ratchets on applications in which the pump reversal time from shutdown (the instant the stop button is pressed) to zero speed is less than one second.

3.4 Installation for belt drive

In general, power transmission though direct flexible coupling is appropriate for large motors. Such motors are not suitable for belt, chain or gear connection unless specially designed for such service. However, for small and medium motors of which outputs within the ranges shown on table below, it is acceptable to use belt transmission as indicated. Beyond these ranges, do not apply belt sheaves unless specially designed.

3.4.1

The diameter ratio between conveyance sheaves should not be greater than 5 to 1 for flat belts, and 8 to 1 for V-belts. It is also advisable to limit the belt velocity to under 35m/sec (115 ft/sec) to limit belt abrasion and vibration. The smaller the outer diameter of the V-belt sheave, the greater the shaft bending stress will be. If the bending stress is in excess of the shaft fatigue stress, the shaft may break. Therefore, please inform TWMC when you have decided the size of the sheaves and the length of the belts upon ordering.

ATTENTION!
Place the sheave and belt as close as possible to the motor body (it is advisable to make x as shown in Fig. 11 equal to 0) to reduce the bending moment and improve shaft life.

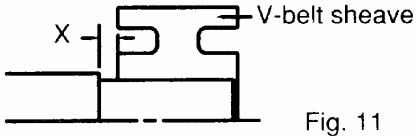


Fig. 11

3.4.2 Table of belt-sheave application for general electric motors

Output (KW/HP)			V-Belt Sheave							
			Conventional V-Belts				Narrow V-Belts			
4P	6P	8P	V-Belt Type	Number Of Belts	Min. PCD (mm)	Max Width (mm)	V-Belt Type	Number Of Belts	Min. PCD (mm)	Max Width (mm)
11/15	-	-	B	4	160	82	3V	4	125	48
-	11/15	-	B	5	170	101	3V	5	140	59
-	-	11/15	B	5	190	101	3V	6	160	69
15/20	-	-	B	5	170	101	3V	6	125	69
-	15/20	-	B	5	224	101	3V	6	160	69
-	-	15/20	C	4	224	111	5V	3	180	60
18.5/25	-	-	B	5	200	101	3V	6	140	69
-	18.5/25	-	C	4	224	111	5V	3	180	60
-	-	18.5/25	C	5	224	136	5V	4	180	78
22/30	-	-	B	5	224	101	5V	6	160	69
-	22/30	-	C	5	224	136	3V	4	180	78
-	-	22/30	C	5	250	136	5V	4	200	78
30/40	-	-	C	5	224	136	5V	4	180	78
-	30/40	-	C	5	265	136	5V	4	224	78
-	-	30/40	C	6	265	162	5V	5	224	95
37/50	-	-	C	6	224	162	5V	4	200	78
-	37/50	-	C	6	265	162	5V	4	224	78
-	-	37/50	C	7	280	187	5V	5	250	95
45/60	-	-	C	6	265	162	5V	4	224	78
-	45/60	-	C	7	280	187	5V	5	224	95
-	-	45/60	C	7	315	187	5V	6	250	113
55/75	-	-	C	7	265	187	5V	5	224	95
-	55/75	-	C	8	300	213	5V	6	250	113
-	-	55/75	D	5	355	196	5V	6	280	113
75/100	-	-	C	8	315	213	5V	6	250	113
-	75/100	-	D	6	355	233	5V	6	315	113
-	-	75/100	D	6	400	233	5V	6	355	113
-	90/120	-	D	6	400	233	5V	6	355	113
-	-	90/120	D	6	425	233	8V	4	355	124
-	110/150	-	D	7	400	270	8V	4	355	124
-	132/175	110/150	D	7	450	270	8V	4	400	124
-	160/200	132/175	D	9	450	344	8V	4	450	124

3.5 Conveyance with chain or gear

3.5.1

Make sure the loading capacity of shaft and bearings is appropriate for the size and installation position (overhung) of chain and gear. If necessary, please contact us to ensure the shaft and bearings will meet your requirements.

3.5.2
Pay close attention to ensure the parallelism of shafts.

3.5.3
The teeth of couplings should be correctly and precisely matched; the force conveyance centers should lie on the same line.

3.5.4
There should be no skip, jumping, vibration or unusual noises.

ATTENTION!
Do not hammer the conveyance devices such as couplings, belt sheaves, chain wheels, gears etc. onto the shaft. Those shaft fitments should be fitted and removed only by means of suitable devices. Heat shrinking may be a better alternative to avoid damaging bearings and components.

The exposed rotating parts should be covered to prevent accidents.

3.6 Electrical connections

All interconnecting wiring for controls and grounding should be in strict accordance with local requirements such as the USA National Electrical Code and UK IEE wiring regulations. Wiring of motor and control, overload protection and grounding should follow the instructions of connection diagrams attached to the motor.

3.6.1 Power

The rated conditions of operation for the motor are as shown on the nameplate. Within the limits, given below, of voltage and frequency variation from the nameplate values, the motor will continue to operate but with performance characteristics that may differ from those at rated conditions:

±10% of rated voltage
±5% of rated frequency
±10% combined voltage and frequency variation so long as frequency variation is no more than ±5% of rated.

Operating the motor at voltages and frequencies outside of the above limits can result in both unsatisfactory motor performance and damage to or failure of the motor.

3.6.2
The main lead box furnished with the motor has been sized to provide adequate space for the make-up of the connections between the motor lead cables and the incoming power cables.

The bolted joints between the motor lead and the power cables must be made and insulated in a workman-like manner following the best trade practices.

3.6.3
Either fabricated motors or fan cooled cast frame, motors are all provided with grounding pads or bolts.

The motor must be grounded by proper connection to the electrical system ground.

3.6.4

The rotation direction of the motor will be as shown by either a nameplate on the motor or the outline drawing. The required phase rotation of the incoming power for this motor rotation may also be stated. If either is unknown, the correct sequence can be determined in the following manner: While the motor is uncoupled from the load, start the motor and observe the direction of rotation. Allow the motor to achieve full speed before disconnecting it from the power source. Refer to the operation section of these instructions for information concerning initial start-up. If resulting rotation is incorrect, it can be reversed by interchanging any two (2) incoming cables.

3.6.5 Auxiliary devices

Auxiliary devices such as resistance temperature detectors, thermocouples, thermoguards, etc., will generally terminate on terminal blocks located in the auxiliary terminal box on the motor. Other devices may terminate in their own enclosures elsewhere on the motor. Such information can be obtained by referring to the outline drawing. Information regarding terminal designation and the connection of auxiliary devices can be obtained from auxiliary drawings or attached nameplates.

If the motor is provided with internal space heaters, the incoming voltage supplied to them must be exactly as shown by either a nameplate on the motor or the outline drawing for proper heater operation.

Caution must be exercised anytime contact is made with the incoming space heater circuit as space heater voltage is often automatically applied when the motor is shutdown.

4. OPERATION

4.1 Examination before start

4.1.1

When motors are installed in good manner, ensure the wiring is according to the diagram. Also, the following points should be noted:

(a) Make sure all wiring is correct.
(b) Ensure the sizes of cable wires are appropriate and all connections are well made for the currents they will carry.
(c) Ensure all connections are properly insulated for the voltage and temperature they will experience.
(d) Ensure the capacity of fuses, switches, magnetic switches and thermo relays etc. are appropriate and the contactors are in good condition.
(e) Make sure the frame and terminal box are grounded.
(f) Make sure that the starting method is correct.
(g) Make sure switches and starters are set at their right positions.
(h) Motor heaters must be switched off when the motor is running.

4.1.2 Measurement of insulation resistance

During and immediately after measuring, the terminals must not be touched as they may carry residual dangerous voltages. Furthermore, if power cables are connected, make sure that the power supplies are clearly disconnected and there are no moving parts.

(a) For rated voltage below 1000V, measured with a 500VDC megger.
(b) For rated voltage above 1000V, measured with a 1000VDC megger.
(c) In accordance with IEEE 43, clause 9.3, the following formula should be applied:

$$R \geq \left(\frac{\text{Rated voltage (v)}}{1000} + 1 \right) \times 10(M\Omega)$$

(d) On a new winding, where the contaminant causing low insulation resistance is generally moisture, drying the winding through the proper application of heat will normally increase the insulation resistance to an acceptable level. The following are several accepted methods for applying heat to the winding:
   (1) If the motor is equipped with space heaters, they can be energized to heat the winding.
   (2) Direct current (as from a welder) can be passed through the winding. The total current should not exceed approximately 50% of rated full load current. If the motor has only three leads, two must be connected together to form one circuit through the winding. In this case, one phase will carry the fully applied current and each of the others, one-half each. If the motor has six leads (3 mains and 3 neutrals), the three phases should be connected into one series circuit.

Ensure there is adequate guarding so live parts cannot be touched.

   (3) Heated air can either blown directly into the motor or into a temporary enclosure surrounding the motor. The source of heated air should preferably be electrical as opposed to fueled (such as kerosene) where a malfunction of the fuel burner could result in carbon entering the motor.

ATTENTION!
Caution must be exercised, when heating the motor with any source of heat other than self contained space heaters, to raise the winding temperature at a gradual rate to allow any entrapped moisture to vaporize and escape without rupturing the insulation. The entire heating cycle should extend over 15-20 hours.

Insulation resistance measurements can be made while the winding is being heated. However, they must be corrected to 40ºC for evaluation since the actual insulation resistance will decrease with increasing temperature. As an approximation for a new winding, the insulation resistance will approximately halve for each 10ºC increase in insulation temperature above the dew point temperature.

(e) Should the resistance fail to attain the specified value even after drying, careful examination should be undertaken to eliminate all other possible causes, if any.

4.1.3 Power Source

(a) Ensure the capacity of the power source is sufficient.
(b) Ensure the supply voltage and frequency ratings are identical to those on the nameplate.
(c) Voltage variation should be confined to within ±10% of the rated value and the phase to phase voltages should be balanced.

4.1.4 Bearing lubrication

(a) For sleeve bearing motors, the oil reservoir must be filled with oil to the correct level. On self-lubricated bearings, the standstill oil level will be at the center of the oil gauge. The proper oil is a rust and oxidation inhibited, turbine grade oil. Refer to the lubrication nameplate for the recommended viscosity.

(b) Motors, which are supplied with provision for flood lubrication, have an inlet orifice to meter the oil flow to the bearing. Refer to the outline drawing for these values. If the supply pressure does not match that stated on the outline, the orifice size must be adjusted to produce the specified flow rate. The drain adapter (also provided) has a weir plate fixed to the inside of the pipe to permit the establishment of the proper oil level. This weir plate must be located at the bottom of the pipe and must be parallel to the plane of the motor feet. To ensure optimum flow, the drain line should be vented to the atmosphere.

Oil inlet temperature:	Normal below 50ºC
	Alarm 60ºC
	Trip 65ºC

(c) If the motor is in storage for over three (3) months, refilling of some new oil should be undertaken before operation to prevent bearing damage due to dry friction. The oil level should be kept at the center of the oil gauge. If necessary, drain some oil after refilling.

(d) Motors that have been designed with anti-friction bearings for use with an oil mist lubrication system have been packed at the factory with a small amount of grease for short test runs. Continuous running should not be considered unless the oil mist system is installed and operating.

(e) Grease lubricant type

(1) The bearings have been well greased at the factory before delivery. However, regreasing is required if a significant period has elapsed between manufacture and use or in storage

(2) All motors with ZZ bearings will have SHELL Alvania R3 (*Lithium base grease*). All motors with open bearings will have Polyrex EM (polyurea base grease).

4.1.5 Cooling water for the cooler on water-cooled motors

Make sure the quality, volume and inlet temperature of cooling water for the motors are normal before the machine is in operation.

Water: General tower water or industrial water.
Volume: Please see outline drawing

Inlet temperature:	Normal below 30ºC
	Alarm 35ºC
	Trip 40ºC

ATTENTION!
Make sure all locks, which fasten the movable parts of the motors during transportation, are dismantled and the shaft can rotate freely.

ATTENTION!
Ensure there is no foreign matter or tools inside the motors before starting motors.

4.1.6
Make sure the transmission system, including belts, screws, bolts, nuts and set pins are in good condition.

The keys fitted to the shaft extensions are held by plastic tape only to prevent them from falling out during transportation or handling. The shaft key shall be removed to avoid flying out, when the motor is operated prior to the couplings etc. being fitted to the shaft extension.

4.1.7
Make sure the items above are examined. Test the motor running with or without load. Record and check according to "Maintenance" at 15-minute intervals during the first three hours of operation. Then regular examinations should take place at longer intervals. If all goes well the motor can be classified as "in good order".

4.2 Starting operation

4.2.1 Starting load
Initially run the motor unloaded prior to coupling to other machines. Unless otherwise specified, a motor usually starts with light load, which is then gradually increased, proportional to the square of the speed and at last reaches 100% load at full load speed.

4.2.2 Starting
Too frequent starts can be harmful to the motors. The following restrictions should be observed:

(a) Motor can be restarted should the initial start fail. Two starts are generally permissible when the motor is cold.
(b) Motor can be started only once when it is at normal running temperature.
(c) Should additional starts be necessary beyond the conditions stated above, the following restrictions should be noted:
    (1) Let the motor cool down for 60 minutes before restarting, fully loaded.
    (2) Let the motor cool down for 30 minutes before restarting, unloaded.
    (3) Two inching starts can be regarded as one normal start.

ATTENTION!
If the motor rotor fails to start turning within one or two seconds, shut off the power supply immediately.
Investigate thoroughly and take corrective action before attempting a restart.

Possible reasons for not starting are:
(1) Too low a voltage at the motor terminals.
(2) The load is too much for the rotor to accelerate.
(3) The load is frozen up mechanically.
(4) All electrical connections have not been made.
(5) Single-phase power has been applied.
(6) Any combination of the above.

4.2.3 Rotating direction

(a) Most TWMC motors are bi-directional. However, when some special types, such as high speed 2-Pole, certain large capacity motors, those with a non-reversing ratchet etc., should rotate in one direction, please ensure the rotation is in conformity with the directional arrow-mark shown on the attached nameplate.

(b) To reverse a bi-directional motor, cut the power and wait until the motor stops. Then interchange any two of the three phases.

4.2.4 Power source, Voltage, Current

(a) Ensure the voltage and frequency of the power source are identical to the ratings shown on the nameplate.

(b) Voltage variation should be confined to within ±10% of the rating and the three phase voltages should be in full balance

(c) Ensure the motor phase currents, when without load, are within ±5% of the average values.

4.2.5

Frequency variation should be confined to within ±5% of the rating. The aggregate variation of voltage and frequency should be confined to within ±10% of the absolute value of the ratings.

Starting time and unusual noises

ATTENTION!
Starting time is longer for the motors with large inertia. However, if starting time is longer than usual or if there is difficulty in starting, or there is abnormal noise, do not run the motor and refer to TWMC Service representative.

4.2.6 Sleeve bearing oil rings (sleeve bearing types only)

As the oil ring is used to carry lubricant to sleeve bearings, frequently check to ensure the oil ring is in motion.

4.2.7 Bearing temperature rise

Following the initial start-up, the bearing temperatures should be closely monitored. The rate of rise in bearing temperature is more indicative of impending trouble than is the actual temperature.

ATTENTION!
If the rate of rise in temperature is excessive or if the motor exhibits excessive vibration or noise, it should be shut down immediately and a thorough investigation made as to the cause before it is operated again.

If the bearing temperature rise and motor operation appear to be normal, operation should continue until the bearing temperature stabilizes.

Recommended limits on bearing temperature are as follows:

Sleeve Bearings	**Total measured temperature**
• By permanently installed detector	90ºC
• By temporary detector on top of the bearing sleeve near the oil ring	85ºC

Anti-Friction Bearings	**Total measured temperature**
• By permanently installed detector	100ºC
• By temporary detector measuring the outside of the bearing housing	95ºC

ATTENTION! (For sleeve bearing)

(1) It must be noted that when operating flood lubricated sleeve bearings without outside lubrication supplied, the bearing temperature must not be allowed to exceed 85ºC total temperature

(2) Under normal condition, for the self-lube bearing, the rate of temperature rise should be from 11 to 14ºC for the first ten (10) minutes after starting up and approximately 22ºC at thirty (30) minutes. The rate of bearing temperature rise is a function of the natural ventilation and operating conditions.

(3) When the rate of bearing temperature rise is less than 1ºC per half-hour, the bearing temperature is considered to be stabilized.

(4) If the total bearing temperature exceeds 95ºC, the motor should be shut down immediately.

Noise and Vibration

ATTENTION!

Any abnormal noise or vibration should be immediately investigated and corrected. Increased vibration can be indicative of a change in balance due to mechanical failure of a rotor part, a stator winding problem or a change in motor alignment.

5. MAINTENANCE

5.1 Major points in regular inspections and maintenance.

For safety, maintenance and repairs must only be carried out by properly trained personnel.

Some testing, such as insulation resistance, usually requires the motor to be stopped and isolated from power supplie(s).

Routine inspection and maintenance are usually performed by looking, listening, smelling and simple meters.

High temperature may arise under operating conditions on the motor surfaces, so that touching should be prevented or avoided. Keep away from moving and live parts. Unless deemed necessary, do not remove guards whilst assessing the motor.

Timely replacement of worn parts can assure longevity and prevent breakdown.

Routine inspection and regular inspection and maintenance are important in preventing breakdown and lengthening service life.

Owing to the varied time and circumstances, motors are used, it is difficult to set the items and periods for regular inspection and maintenance. However, as a guide it is recommended to be performed periodically according to factory maintenance program. Generally, the inspection scope determined by the following factors:

(a) Ambient temperature.
(b) Starting and stopping frequency.
(c) Troublesome parts usually affecting motor functions.
(d) Easily abraded parts.
(e) The important position of motor in the operational system of a factory should be duly recognized. Therefore, its health and wellbeing should be fully protected especially when it is operating in severe conditions.

5.2 Motor windings:

(a) Measurement of insulation resistance and standards to determine quality of insulation resistance, please refer to measures stated in 4.1.2 “Measurement of insulation resistance”.
(b) Inspection of coil-ends:
    (1) Grease and dust accumulated on coils may cause insulation deterioration and poor cooling effect.
    (2) Moisture must not accumulate. Keep coils warm when motor is not in use if moisture can be seen.
    (3) Discoloring. This is mainly caused by overheating.
(c) Ensure no untoward change of wedges from original position.
(d) Ensure the binding at the coil end is in its normal position.

5.3 Clean the interior of the motor:

(a) After a motor is in operation for some time, accumulation of dust, carbon powder and grease etc., on the inside is unavoidable, and may cause damage. Regular cleaning and examination is necessary to assure top performance.
(b) Points to note during cleaning:
    (1) If using compressed air or blower:
        (a) Compressed air should be free of moisture.
        (b) Maintain air pressure at 4 kg/cm^2, since high pressure can cause damage to coils.
    (2) Vacuum
        Vacuum cleaning can be used, both before and after other methods of cleaning, to remove loose dirt and debris. It is a very effective way to remove loose surface contamination from the winding without scattering. Vacuum cleaning tools should be non-metallic to avoid any damage to thee winding insulation
    (3) Wiping
        Surface contamination on the winding can be removed by wiping using a soft, lint-free wiping material. If the contamination is oily, the wiping material can be moistened (not dripping wet) with a safety type petroleum solvent. In hazardous locations, a solvent such as inhibited methyl chloroform may be used, but must be used sparingly and immediately removed. While this solvent is non-flammable under ordinary conditions, it is toxic and proper health and safety precautions should be followed while using it.

ATTENTION!
Solvents of nay type should never be used on windings provided with abrasion protection. Abrasion protection is a gray, rubber-like coating applied to the winding end-turns.

Adequate ventilation must always be provided in any area where solvents are being used to avoid the danger of fire, explosion or health hazards. In confined areas (such as pits) each operator should be provided with an airline respirator, a hose mask or a self-contained breathing apparatus. Operators should wear goggles, aprons and suitable gloves. Solvents and their vapors should never be exposed to open flames or sparks and should always be stored in approved safety containers.

(4) Keep core ducts completely clean. The difference in temperature rise could be around 10℃ before and after cleaning

5.4 Clean the exterior of the motor:

(a) On open ventilated motors, screens and louvers over the inlet air openings should not be allowed to accumulate any build-up of dirt, lint, etc. that could restrict free air movement.

ATTENTION!
Screens and louvers should never be cleaned or disturbed while the motor is in operation because any dislodged dirt or debris can be drawn directly into the motor.

(b) If the motor is equipped with air filters, they should be replaced (disposable type) or cleaned and reconditioned (permanent type) at a frequency that is dictated by conditions. It is better to replace or recondition filters too often than not often enough.

(c) Totally enclosed air to air cooled and totally enclosed fan cooled motors require special cleaning considerations. The external fan must be cleaned thoroughly since any dirt build-up not removed can lead to unbalance and vibration. All of the tubes of the air-to-air heat exchanger should be cleaned using a suitable tube brush having synthetic fiber bristles (not wire of any type).

5.5 Maintenance of anti-friction bearings

5.5.1 Frequency of re-lubrication:

The life of grease varies greatly as a result of types of model, revolution speed, temperature, operational conditions etc. It is, therefore, impossible to be precise about replenishment intervals. However, for normal direct coupling transmission, the periods shown as Table 1 may be used as a guide.

Remarks:

(a) The periods shown in Table 1 should be halved where bearings are used for belt drive and/or in dirty or high ambient temperature or high humidity environments.

(b) Please refer to the lubrication nameplate, if attached to the motor.

(c) For bearing numbers outside the range of Table 1, please contact TWMC

(d) If the periods referred to in Table 1 for drive-end bearing and opposite drive-end are different, for the convenience of maintenance operation, please take the shorter one the required grease replenishment period of these bearings.

5.5.2 Kinds of grease:

All motors with ZZ bearings will have SHELL Alvania R3 (lithium base grease). All motors with open bearings will have Polyrex EM (polyurea base grease).
Certain T-frame models will utilize special grease and will be noted on the lubrication nameplate. Please us identical grease or its equivalents when maintaining lubrication schedule.

ATTENTION!
Do not mix different kinds of grease.
Mixing grease with different type of thickeners may destroy its composition and physical properties. Even if the thickeners are of the same type, possible differences in the additive may cause detrimental effects.

5.5.3 Grease quantity

The amount of grease per replenishment depends on the type, size and construction of the bearings. The maximum amount of one replenishment for each bearing is shown in Table 2.

5.5.4 Re-greasing

If re-lubrication is to be performed when the motor is running, stay clear of rotating parts.

It is advisable to re-grease when the motor is running to allow the new grease to be evenly distributed inside the bearing.
Before re-greasing, the inlet fitting should be thoroughly cleaned to prevent any accumulated dirt from being carried into the bearing with the new grease. The outlet of grease drainage should be opened to allow the proper venting of old grease.

Use a grease gun to pump grease through grease nipple into the bearings. After re-greasing, operate the motor for 10-30 minutes to allow any excess grease to vent out.

TABLE 1.

Bearing Number		600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM	3000 RPM	3600 RPM
62XX 63XX 72XX 73XX	6210										
	12									2000 Hrs.	
	13										
	14									1000 Hrs.	
	15										
	16									720 Hrs.	
	17							2000 Hrs.			
	18			3000 Hrs.							
	20										
	22										
	24							1500 Hrs.			
	26										
	28					2000 Hrs.		1000 Hrs.			
	30										
	32							500 Hrs.			
	34					1500 Hrs.					
	36										
	38			2000 Hrs.		1000 Hrs.					

Bearing Number		600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM
NU2XX NU3XX	NU214								
	15							2000 Hrs.	
	16								
	17								
	18			3000 Hrs.				1500 Hrs.	
	20								
	22							1000 Hrs.	
	24								
	26					2000 Hrs.			
	28							500 Hrs.	
	30								
	32								
	34			2000 Hrs.		1000 Hrs.			
	36								
	38	2000 Hrs.							
	40								
	44			1000 Hrs.					
	48	1000 Hrs.							

Bearing Number		600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM
222XX 223XX	22220							300 Hrs.	
	22								
	24			1000 Hrs.		500 Hrs.			
	26								
	28								
	30					300 Hrs.			
	32			500 Hrs.					
	34								
	36								
	38	500 Hrs.							
	40			300 Hrs.					
	44								
	48	300 Hrs.							

TABLE 2.

Bearing No.		Amount of replenishment
62XX 72XX NU2XX 2222XX	6210	30 g
	6212	40
	6213	50
	6214	50
	6215	60
	6216	60
	6217	80
	6218	80
	6220	100
	6222	120
	6224	120
	6226	140
	6228	160
	6230	180
	6232	200
	6234	250
	6236	300
	6238	350
	6240	400
	6244	450
	6248	500

Bearing No.		Amount of replenishment
63XX 73XX NU223XX 223XX	6310	40 g
	6312	60
	6313	80
	6314	80
	6315	100
	6316	100
	6317	120
	6318	120
	6320	160
	6322	220
	6324	270
	6326	300
	6328	400
	6330	450
	6332	500
	6334	600
	6336	700
	6338	800
	6340	900
	6344	900
	6348	900

*Fill new grease until it overflows and the old grease is entirely replaced.

5.5.5 Oil re-lubrication (For oil lubrication types only)

Maintain proper lubrication by checking the oil level periodically and adding oil when necessary. Because of the initial clearing action of the bearing and the expansion of the oil as it comes up to operating temperature, the oil level will be higher after the motor has been in operation for a while than it is with the motor at standstill.

Overfilling should be avoided not only because of the possibility that expansion may force the oil over the oil sleeve and on to the rotor, but also because too high an operating oil level prevents the bearing form clearing itself of excess oil. The resultant churning can cause extra loss, high temperatures, and oxidized oil. If, during operation, the oil level goes above the maximum shown on the sight gauge, drain enough oil to bring the level back within the recommended operating range. **Do not permit the operating level to fall below the minimum shown on the gauge.**

ATTENTION!
Should it ever become necessary to add excessive amount of make-up oil, investigate immediately for oil leaks.

Change the oil at regular intervals. The time between oil changes depends upon the severity of operating conditions and, hence, must be determined by the motor user. Two or three changes a year is typical, but special conditions, such as high ambient temperature, may require more frequent changes. Avoid operating the motor with oxidized oil.

Use only good grade, oxidation-corrosion-inhibited turbine oils produced by reputable oil companies.

The viscosity of the oil to be used depends upon the type and size of the bearings, its load and speed, the ambient temperature, and the amount and temperature of the cooling water (if used)). The lubrication nameplate or instructions with each motor specifies the viscosity range of oil suitable for average conditions. The usual oil viscosity range of oil suitable for average conditions. The usual oil viscosity recommendations are summarized in Table 3. Operation in ambient temperatures that are near or below freezing may require preheating the oil or the use of special oil. Whenever the motor is disassembled for general cleaning and reconditioning, the bearing housing may be washed out with a suitable cleaning solvent. Be sure that the oil-metering hole is clear, and then dry the housing thoroughly before re-assembly, and ensure all traces of cleaning solvent have been removed.

TABLE 3 Oil Viscosity**

Bearing function and location	Bearing Type	Oil Viscosity - SSU	
		@ 100℉	@ 200℉
Thrust Bearing	72XX, 73XX Angular contact ball And/or (62XX, 63XX)	150	45
	Spherical roller	300	53
	Plate (Kingsbury Type)	300	53

**Remark: When a lubrication nameplate attached to the motor, use lubrication oil it stipulates.

5.5.6 Cleaning and installation of bearings

(a) Apply the proper amount of grease to the disassembled parts of the bearing after they have been thoroughly cleaned with high quality cleaning oil. Then protect them from contamination before and during assembly.

(b) Bearing installation

ATTENTION!
Before installing the bearings, make sure that the shaft mounted parts inside the bearings are in place before installation.

Since the bearing is a high precision component, it is important to avoid ingression of dust and foreign matter, and hammering during cleaning and installation. Use extreme care and insure clean conditions during installation and assembly.

ATTENTION!
The best way for bearing installation is heat shrinking. Knocking and hammering during installation should be avoided absolutely.

The bearing should be heated in a bath of clean oil at a temperature of approximately 80℃. After warming, slide the bearings in place quickly and nimbly so that it has not shrunk before being fully in position.
Grease the bearing after the temperature returns to normal, and then reassemble the motor.

5.6 Maintenance of sleeve bearings

5.6.1 Daily inspections

(a) Ensure the volume and quality of lubrication oil are in compliance with specifications.

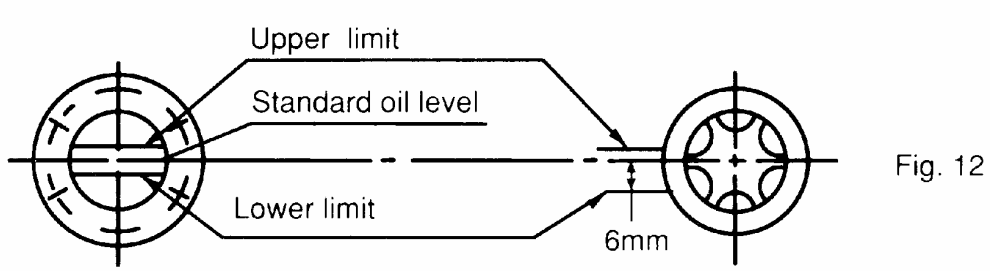


Fig. 12

(b) Ensure there is motion of the oil ring and it is not clamped.

(c) The indicator of the shaft endplay should be restricted within the specified range of the red groove of the shaft or the ±3mm (.118 in.) range of the drive-end shaft shoulder, or the bearing may be damaged.

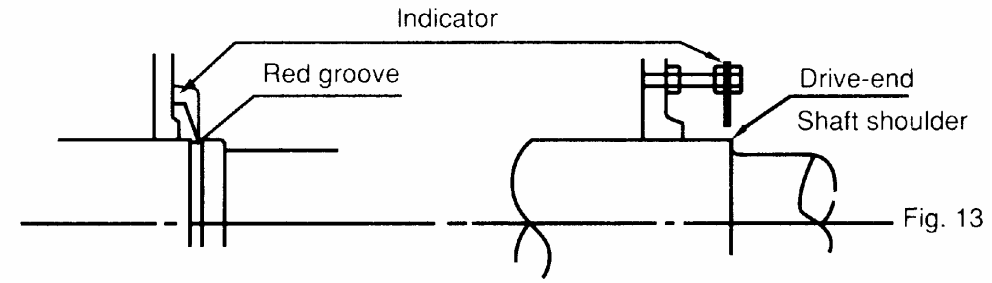


Fig. 13

5.6.2 Regular examination

(a) Periodical change of oil

The oil reservoirs of self (not flood) lubricated bearings should be drained and refilled about every six (6) months. More frequent changes may be needed on high speed (3600 rpm) motors or if severe oil discoloration or contamination occurs. In conditions where contamination does occur, it may be advisable to flush the reservoir with kerosene to remove any sediment before new oil is added. Proper care must be taken to thoroughly drain the reservoir of the flushing material before refilling with the new oil.

Refill the reservoir to the center of oil sight glass with a rust and oxidation inhibited turbine grade oil. Refer to the outline and lubrication nameplate for the correct viscosity.

(b) Quantity of lubrication oil

Please refer to the lubrication nameplate for oil quantity.

(c) Oil viscosity

(d)

ISO	Equivalents	Viscosity (SUS/100℉)
VG32	Esso Teresso 32	150
VG46	Esso Teresso 46	200
VG68	Esso Teresso 68	300

5.6.3 Disassembly

Prior to disassembling, ensure the power supplies are disconnected and there are no moving parts.

The bearing sleeve is of the spherically seated, self-aligning type. The opposite drive end bearing is normally insulated for larger motors (or when specified). On some motors, the insulation is bonded to the spherical seat of the bearing housing.

ATTENTION!
Extreme care must be exercised in removing the bearing sleeve from the insulated support to avoid damaging this insulation.

The following is the recommended procedure for removing the bearing sleeve:

(a) Remove the oil drain plug in the housing bottom and drain the oil sump.

(b) Remove all instrumentation sensors that are in contact with the bearing sleeve. These would include resistance temperature detectors, thermocouples, thermometers, etc..

(c) Remove the socket head bolts holding the bearing cap and the inner air seal. The end cover plate must also be removed if the non-drive end bearing is being disassembled. Remove the bearing cap and top half of the inner air seal. Place them on a clean, dry surface to avoid damage to the parting surfaces.

(d) Remove the top half of the bearing sleeve using suitable eyebolts in the tapped holes provided. Lift the bearing top straight up and avoid any contact with the shoulders of the shaft journals that might damage the thrust faces of the bearing. Place on a clean, dry surface taking care to prevent damage to either the parting surfaces or the locating pins that are captive n the top bearing half.

(e) Remove the screws at the partings in the oil ring and dismantle the ring by gently tapping the dowel pin ends with a soft face mallet. Remove the ring halves and immediately reassemble them to avoid any mix up l parts or damage to the surfaces at the partings.

(f) Pull up on the garter spring surrounding the floating labyrinth seal and carefully slip out the top half. Rotate the garter spring until the lock is visible. Twist counter-clockwise to disengage the lock, remove the garter spring then rotate the lower half of the seal out of the groove in the bearing housing. Note the condition of these floating labyrinth seals. If they are cracked or chipped, they must be replaced. Do not attempt to reuse a damaged seal.

(g) To remove the bottom bearing half, the shaft must be raised a slight amount to relieve pressure on the bearing. On the drive end, this can be done by jacking or lifting on the shaft extension. Protect the shaft. On the non-drive, jacing or lifting can be done using bolts threaded into the tapped holes provided in the shaft end.

(h) Roll the bottom bearing half to the top of the shaft journal and then lift it using suitable eyebolts threaded into the holes provided. Again avoid any contact with the shaft shoulders that could damage the bearing thrust faces. Place the lower bearing half on a clean, dry surface to protect the parting surfaces.

Use extreme care when rolling out the lower bearing half. Keep the hands and fingers well clear of any position where they might be caught by the bearing half if it were accidentally released and rotated back to its bottom position. Serious personal injury could result.

(i) Protect the shaft journal by wrapping it with clean, heavy paper or cardboard.

5.6.4 Re-assembly

Bearing re-assembly is basically a reverse of the disassembly procedures outlined above, with the following suggestions:

(a) The interior of the bearing housing should be cleaned and then flushed with clean oil or kerosene.

(b) The bearing halves and the shaft journal should be wiped clean using lint-free cloth soaked with clean oil.

(c) All parts should be carefully inspected for nicks, scratches, etc., in any contract surfaces. Such imperfections should be removed by an appropriate method such as stoning, scraping, filling, etc., followed by thorough cleaning.

(d) Before installing the floating labyrinth seal halves, observe their condition. Do not attempt to use a cracked or chipped seal. The bottom half seal has a set of drilled holes in its side face. These must be place at the bottom toward the inside of the bearing so that accumulating oil may drain back into the housing.

(e) Put a bead of Curil-T around the seal half O.D.'s on both sides adjacent to the garter spring groove. This will prevent oil by-passing the seal around its outside.

(f) Place the bottom seal half on top of the shaft and roll it into position. Install the top half and insert the garter spring pulling up on both ends to permit engaging the lock. Run a bead of Curil-T around the O.D's on both sides adjacent to the garter spring groove on this half also.

(g) Carefully reassemble the two oil ring halves. Inspect the dowel pins for burrs and straightness and make any corrections required. Do not force the ring halves together. Excessive force may alter the roundness or flatness of the oil ring which can change its oil delivery performance.

(h) Some of the pipe plugs in the housing are metric thread type. These are identified as those, which have a copper, lead, or similar material washer. If these plugs are removed,

be careful not to lose the washers. Before re-assembly, inspect the washers and replace them as required.

(i) Before installing the bearing cap, observe the position of the floating labyrinth seal. The "tab" must be on top to engage the pocket. Failure to position the seal properly will result in damage when the cap is assembled.

ATTENTION!
(1) Curil-T is the only approved compound for use in the assembly of the bearings on this motor. Other products may harden and impede the operation.
(2) During the re-assembly of the bearing parts, a thin layer of Curil-T should be applied to all gaskets and machined interface surfaces. This suggestion does not apply to the machined surfaces of the bearing liner halves.
(3) When seating the bearing shell, apply a thin layer of lube oil at the spherical surface of the liner. Slowly roll the lower bearing liner into the bearing housing making sure that the splinted surface of the liner and the housing are flush. Gradually lower the shaft onto the bearing. The weight of he shaft will help rotate the bearing liner so that the babbitt surface of the liner will match the slope of the journal. Sometimes it is required to use a rubber mallet to tap lightly on the bearing housing while slowly rolling the shaft to help this seating operation.

5.7 Maintenance of slip ring (For Wound Rotor Motors only)

Ensure motor is disconnected from power supplies and there are no accessible moving parts before maintenance operation.

5.7.1 Adjustment of carbon brush

(a) Brush pressure for normal operation:
- Electro-graphite brush…..0.2~0.25 kg/cm²

When frequent vibrations are evident or the brush is small (area below 0.5 cm²), the pressure should be greater than as shown.

(b) Adjustment of brush pressure:
The brush pressure should be adjusted to keep normal operation as it wears.
- The brush pressure may be reduced after use, so it is necessary to re-adjust. For adjustment, please turn adjusting screw, pressure adjusting pin or pressure adjusting plate as shown in Fig. 14 to obtain the correct tension (=0.23 x brush cross sectional area in cm²) ±10% kg.

(c) Brush pressure need not be adjusted if constant force spring is used as shown in Fig. 15 and Fig. 16.

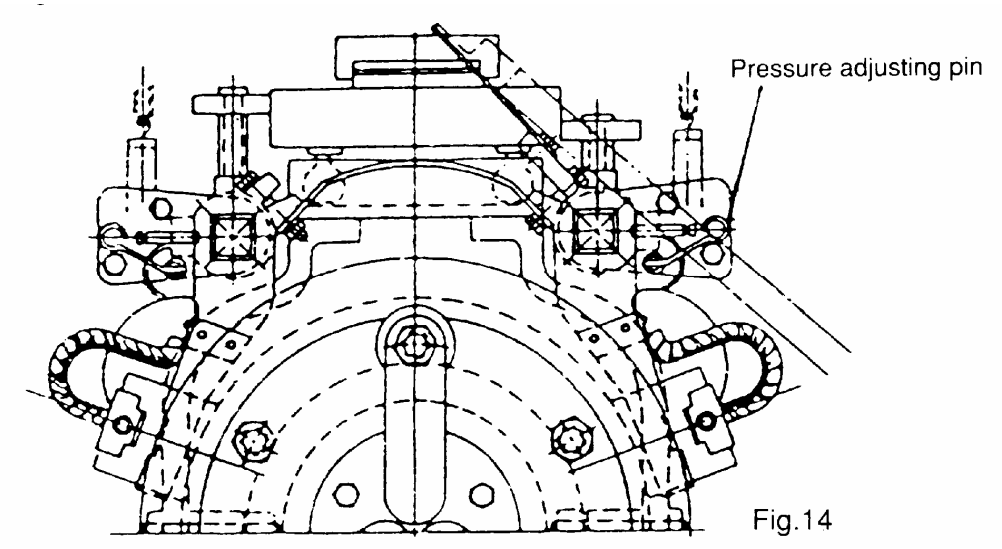


Fig.14

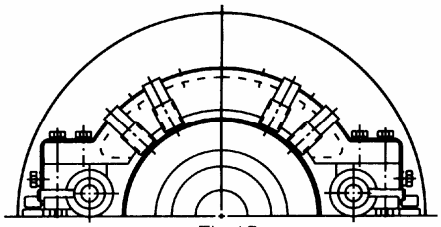


Fig.15

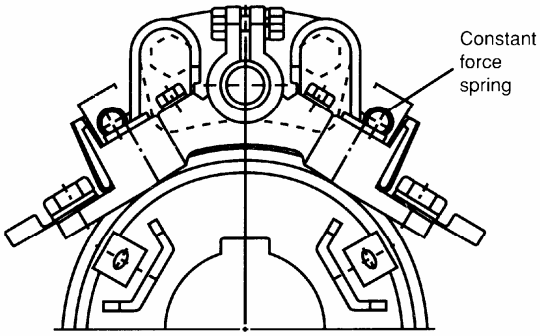


Fig.16

5.7.2 Brush replacement

The carbon brush is a part of the equipment which is easily worn away, replace it after it is worn to ½ ~ ¾ of original size.

(a) Brush material

The brush material is important to the performance of the motor. Only the most appropriate materials are chosen by TWMC, and are listed on the nameplate of the motor. It is important to know this when you replace the brush, so a recommended type is used.

(b) Dimensions

Brush, holder and gap between them, please refer to CNS 2322 C4051 or JIS C2802.

ATTENTION!
The gap between a brush and it holder is important for good performance and safety of the motor.

(c) Adjustment of new brushes (Shown in Fig. 17)

(1) Polish the new brush with a file until is assumes the appropriate contour of the slip ring which it touches.

(2) Place sand-paper (JIS R6252 No. 40…50) on the slip ring with the abrasive face of the paper against the brush to induce a closer contact by rubbing against each other.
(3) Repeat item 2 with fine sand –paper (JIS R6252 No. 100 to 200) until the contact surface between brush and slip ring exceeds 80%.
(4) Finally, clean the contaminated slip ring and brush with clean cloth or compressed air.

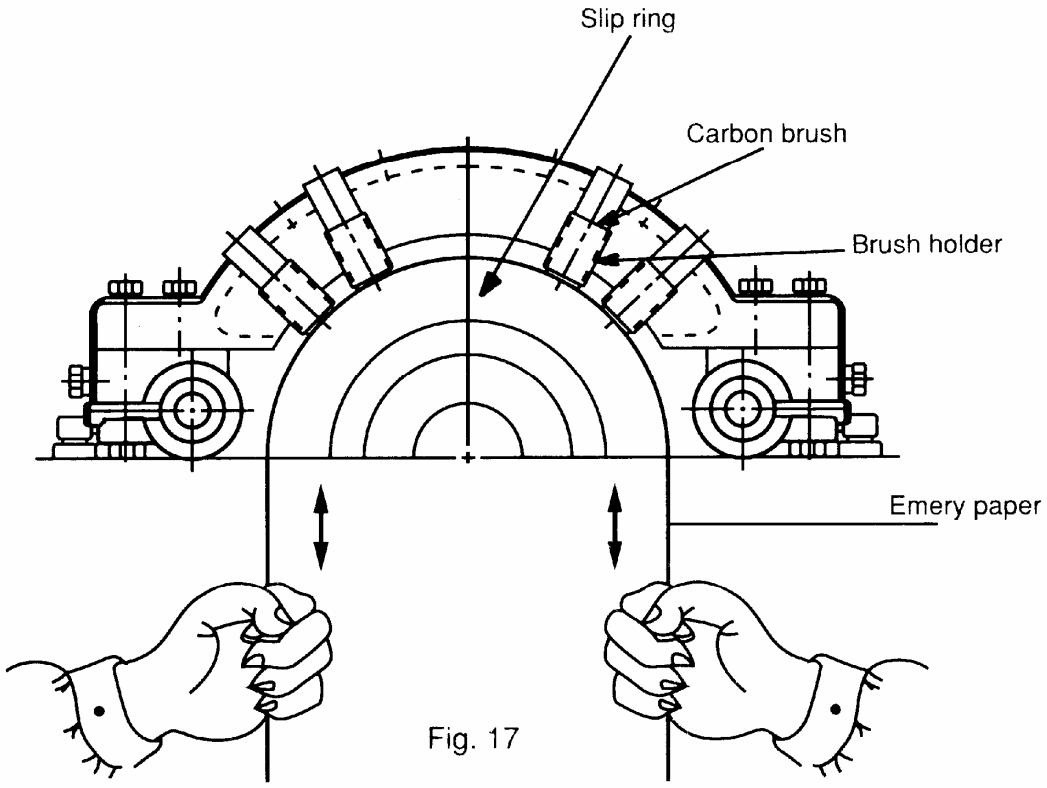


Fig. 17

5.8 Maintenance of non-reverse ratchet mechanism (For Vertical high Thrust Motor only)

5.8.1
In the pump piping system, a check valve and a stop valve should be installed in the discharge line. The check valve, placed between the pump and the stop valve, is to protect the pump from reverse flow and excessive backpressure. The stop valve is used in priming, starting and when shutting down the pump. It is advisable to close the stop valve before stopping the pump. This is especially important when the pump is operated against a high static head.

TWMC vertical high thrust motors are equipped with non-reverse ratchet (N.R.R.) mechanism only when requested by the pump manufacturer. Typical construction of the N.R.R. mechanism is shown as Fig 18 below.

The N.R.R. mechanism keeps the pump and motor from rotating in the reverse direction. Thus prevents damage from over-speeding and damage to water-lubricated pump shaft bearings

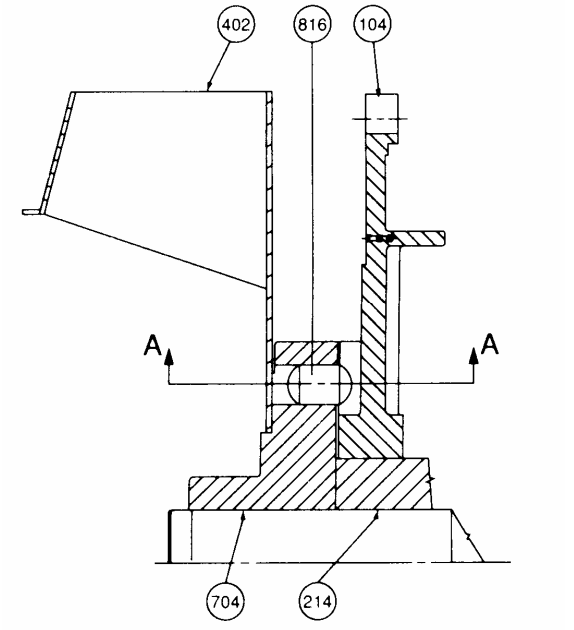
when, on shutdown, the falling water column tends to drive the pump in the reverse direction. In normal operation, the ratchet pins are lifted by the ratchet teeth and are held clear by centrifugal force and friction as the motor comes up to speed. When power is removed, the speed decreases and the pins fall. At the instant of reversal, a pin will catch in a ratchet tooth and prevent backward rotation.

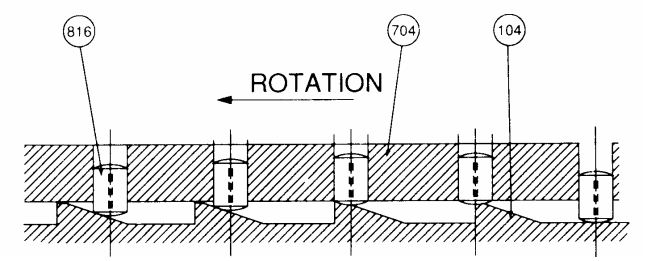
5.8.2

The service life of ratchet pins depends not only on the reverse shock load between the pin and ratchet tooth when pump stopped but also the frequency of pump starting and stopping while in service. Provided that the pins are deformed due to this reverse shock load, then the up and down motion of the ratchet pins could be sluggish or jammed and that unusual noises shall arise.

The recommended replacement period for these ratchet pins is every three (3) years. If the reverse shock load is greater than 30% of motor rated torque or the starting frequency is more than twice per day, then the replacement period should be halved.

ATTENTION!
The check valve and stop valve in the discharge line should be regularly inspected and maintained to assure the normal function of these valves. This is important to protect the pump and motor from damage and increase the service life of the N.R.R. mechanism.





SECTION A-A

ITEM	NAME
104	RATCHET
214	BEARING SEAT
402	EXTERNAL FAN
704	RATCHET PIN CARRIER
816	RATCHET PIN

Fig. 18

6. FAULT FINDING AND RECOGNITION

Kinds of Breakdown	Symptoms	Possible Causes	Remedies
Fail to start without load	Motionless and soundless	Power-off	Consult power company
		Switch-off	Switch-on
		No fuse	Install fuse
		Broken wiring	Check wiring and repair
		Broken lead	Check wiring and repair
		Broken windings	Check windings and repair
	Fuse blowing. (Automatic switch trips off, slow start with electromagnetic noise)	Short circuit of circuit switches	Check circuit switches and replace
		Incorrect wiring	Check wiring according to nameplate
		Poor contact at terminal	Lock tightly
		Windings grounded	Factory repair
		Broken windings	Factory repair
		Poor contact of circuit switches	Check and repair
		Broken wiring	Check and repair
		Poor contact of starting switches	Check and repair
		Short circuit of starting switches	Check and repair
		Incorrect connections of starting switches	Connect according to nameplate
Loading after start	Fuse blowing. Fail to restart due to trip-off of automatic switch	Insufficient capacity of fuse	Replace fuse if wiring permits
		Overload	Lighten load
		High load at low voltage	Check circuit capacity and reduce load
	Overheating motor	Overload or intermittent overload	Lighten load
		Under-voltage	Check circuit capacity and power source
		Over-voltage	Check power source
		Ventilation duct clogged	Remove the foreign matter in the duct
		Ambient temperature exceeds 40°C	Correct insulation class to B or F, or lower ambient temperature
		Friction between rotor and stator	Factory repair
		Fuse blown (Single-phase rotating)	Install the specified fuse
		Poor contact of circuit switches	Check and repair
		Poor contact of circuit starting switches	Check and repair
		Unbalance three-phase voltage	Check circuit or consult power company

Kinds of Breakdown	Symptoms	Possible Causes	Remedies
Loading after start	Speed falls sharply	Voltage drop	Check circuit and powers source
		Sudden overload	Check machine
		Single-phase rotating	Check circuit and repair
	Switch overheat	Insufficient capacity of switch	Replace switch
		High load	Lighten load
	Bearing over-heating	High belt tension	Adjust belt tension
		Slack belt tension	Adjust belt tension
		Misalignment between motor and machine shafts	Re-align
		Over speed of bearing outer-ring	Adjust bracket
		High bearing noise	Replace the damaged bearing
Noise	Electromagnetic noise induced by electricity	Occurrence from its first operation	May be normal
		Sudden sharp noise and smoking	Short circuit of windings should be repaired at the factory
	Bearing noise	Noise of low shishi or Thru-Thru	May be normal
		Kala-Kala as a result of poor lubrication	Grease
		Kulo-Kulo as a result of poor lubrication	Clean bearing and grease
		Sa-Sa or larger noise	Replace the damaged bearing
	Mechanical noise caused by machinery	Loose belt sheave	Adjust key and lock the screw
		Loose coupling or skip	Adjust the position of couplings, lock key and screw
		Loose screw on fan cover	Lock fan cover screw tightly
		Fan rubbing	Adjust fan position
		Rubbing as a result of ingression of foreign matter	Clean motor interior and ventilation ducts
		Wind noise	Noise induced by air flowing through ventilation ducts
		Induced by conveyance machine	Repair machine
Vibration	Electromagnetic vibration	Short circuit of winding	Factory repair
		Open circuit of rotor	Factory repair
	Mechanical vibration	Unbalanced rotor	Factory repair
		Unbalanced fan	Factory repair
		Broken fan blade	Replace fan
		Unsymmetric centers between belt sheaves	Align central points
		Central points of couplings do not lie on the same level	Adjust the central points of couplings to the same level
		Improper mounting installation	Lock the mounting screws
		Motor mounting bed is not strong enough	Reinforce mounting bed

Remarks:

(1) Circuit switches: These include knife switches, electromagnetic switches, fuse and other connection switches etc.

(2) Starting switches: These include Delta-Star starters, compensate starters, reactance starters, resistor starters, starting controller's etc.