8966

US Army Corps of Engineers

Toxic and Hazardous Materials Agency

FINAL HEALTH AND SAFETY PLAN

Fort Douglas
Environmental Investigation/Alternatives Analysis

Contract Number DAAA-15-90-D-0018
Task Order 0005, Data Item A008

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

Prepared For

Commander
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland 21010-5401

Prepared By

R. L. Stollar & Associates Inc.
URS Consultants, Inc.
PTI Environmental Services
Urie Environmental Health, Inc.
DataChem Laboratories
Environmental Science & Engineering, Inc.
Environmental Hazards Specialists
International, Inc.

20061219206

September 1991

THAMA Form 45, 1 Jul 90

FINAL HEALTH AND SAFETY PLAN

SEPTEMBER 1991

CONTRACT NO. DAAA-15-90-D-0018

TASK ORDER 0005

FORT DOUGLAS
ENVIRONMENTAL INVESTIGATION/ALTERNATIVES ANALYSIS

Prepared by:

R. L. STOLLAR & ASSOCIATES INC.
URS CONSULTANTS, INC.
PTI ENVIRONMENTAL SERVICES
URIE ENVIRONMENTAL HEALTH, INC.
DATACHEM LABORATORIES
ENVIRONMENTAL SCIENCE & ENGINEERING, INC.
ENVIRONMENTAL HAZARDS SPECIALISTS INTERNATIONAL, INC.

Prepared for:

U.S. ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY

Distribution Unlimited,
approved for Public Release

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

PAGE

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

AA	Alternatives Analysis
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos containing material
AHERA	Asbestos Hazard Emergency Response Act
ANSI	American National Standards Institute
cc	cubic centimeter
CFR	Code of Federal Regulations
CPC	chemical protective clothing
CPR	cardiopulmonary resuscitation
DB	Dry Bulb Temperature
dBA	decibels (measured using scale A-slow response)
ECT	equivalent chill temperature
EI	Environmental Investigation
EPA	U.S. Environmental Protection Agency
FEIS	Final Environmental Impact Statement
FID	flame ionization detector
GT	Globe Temperature
HASP	Health and Safety Plan
HEPA	high efficiency particulate air
HR	heart rate
IDLH	immediately dangerous to life and health
IP	ionization potential
KV	kilovolt
l/m	liters per minute
lb	pound
LC	lethal concentration
LCL	lower control limit
LD	lethal dose
LEL	lower explosive limit
LFL	lower flammable limit
mg/m^3	milligrams per cubic meter
ml	milliliter
mppcf	millions of particulates per cubic foot

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

mm Hg	millimeters of mercury
MSDS	Material Safety Data Sheets
NCO	non-commissioned officer
NIOSH	National Institute for Occupational Safety and Health
NWT	Natural Wet Bulb Temperature
O_2	oxygen
OSHA	Occupational Safety and Health Administration
OVA	organic vapor analyzer
PA	Preliminary Assessment
PCB	polychlorinated biphenyl
PDS	personnel decontamination station
PEL	permissible exposure limit
PID	photoionization detector
ppb	parts per billion
ppcc	particulates per cubic centimeter
PPE	personal protective equipment
ppm	parts per million
SAP	Sampling and Analysis Plan
SCBA	self-contained breathing apparatus
SSO	Site Safety Officer
Stollar	R. L. Stollar and Associates, Inc.
TEL	tetraethyl lead
TLV	threshold limit value
TWA	Time-weighted average
UST	Underground storage tank
VP	Vapor pressure
WBGT	Wet bulb globe temperature
WGT	Wet globe temperature

1.0 INTRODUCTION

1.1 PURPOSE

This Health and Safety Plan (HASP) addresses the tasks to be performed during the Environmental Investigation/Alternatives Analysis (EI/AA) at Fort Douglas, located on the eastern side of Salt Lake City, Utah. The areas of Fort Douglas that are to be investigated for potential contamination include the military museum, chapel, Noncommissioned Officer's (NCO) club, Officer's club, 39 family housing structures (three of which are used as administrative offices), three detached garages, three structures associated with a former service station, a swimming pool with related water treatment and bath house buildings, various pole-mounted transformers located throughout the site, two abandoned underground hydrocarbon storage tanks (USTs) and a location downgradient of a storage yard. The proposed work tasks include: sampling and inspecting the buildings for the presence of asbestos and lead-based paint, sampling the transformers for polychlorinated biphenyls (PCBs), collecting soil and potentially ground-water samples, and installing ground-water monitoring wells if saturated conditions are observed during drilling. The asbestos survey will be conducted as a separate field program prior to the other field work.

The purpose of this plan is to provide specific health and safety requirements for the planned scope of work. It contains guidelines and directives which establish minimum standards for chemical monitoring and exposure control, safety criteria, and emergency response procedures. This plan is written in such a manner as to allow the Site Safety Officer the ability to respond to changing conditions and make professional judgments regarding the interpretation of monitoring data and related control measures.

This HASP applies to all R.L. Stollar and Associates (RLSA) employees involved in the described scope of work. It is not applicable to other contractors and/or site tasks, unless specifically authorized for such use by a designated Stollar representative.

1.2 SCOPE

The primary scope of work at Fort Douglas will include the following activities:

- Inspection and sampling of the buildings to be excessed for the presence of asbestos.

- Inspection and sampling of the buildings to be excessed for the presence of lead-based paints.
- Sampling of up to 25 transformers for PCBs at locations in and adjacent to the area to be excessed. The exact locations are identified in the Sampling and Analysis Plan (SAP).
- Collection of soil samples and installation of ground-water monitoring wells at points in the area to be excessed. The locations of the boring are identified in the SAP.

1.3 PROPERTY DESCRIPTION

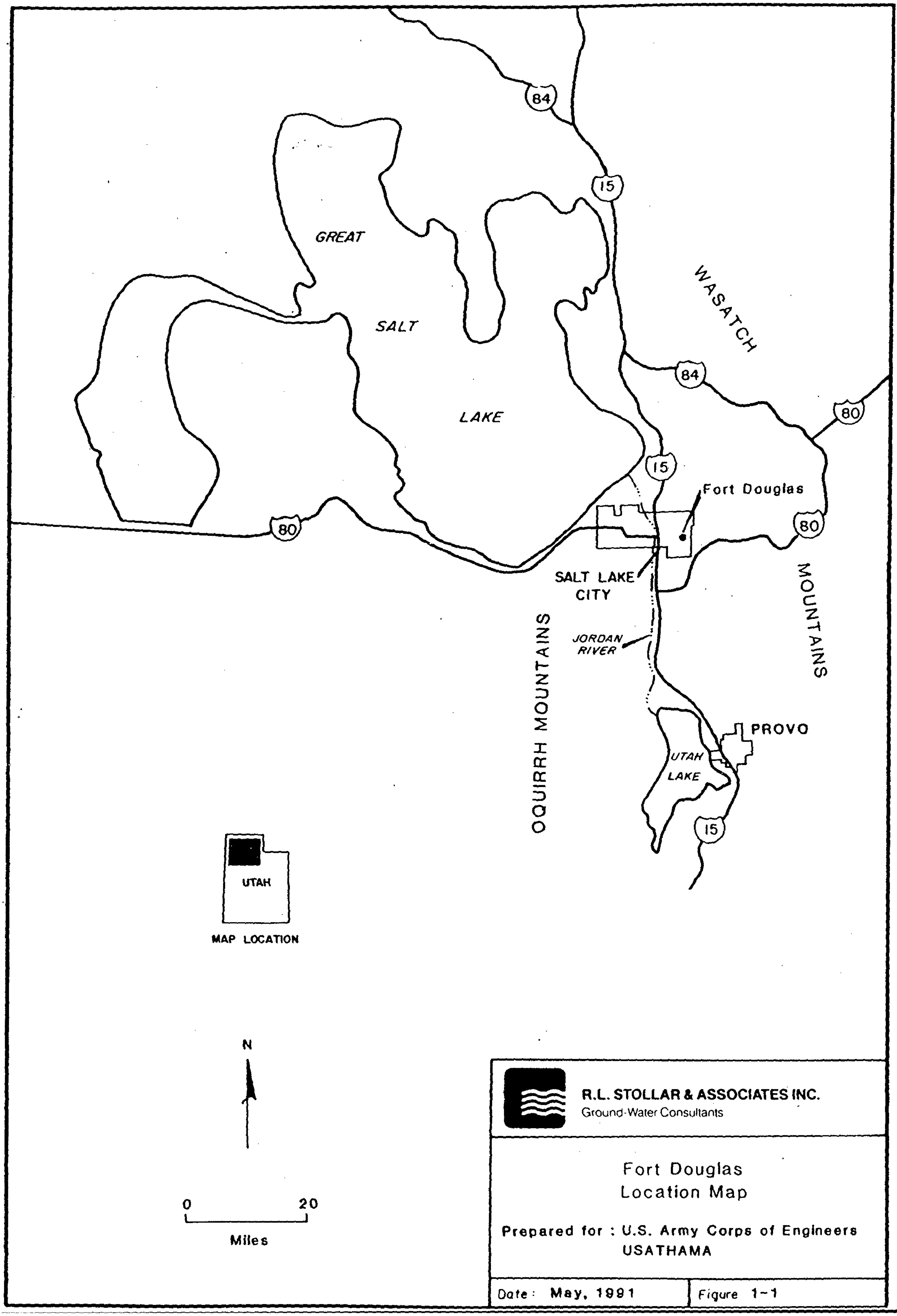
Fort Douglas is an active military installation located on the western slope of the Wasatch Mountains in Salt Lake City, Utah (Figure 1-1). The total land area currently occupied by the base includes approximately 119 acres (Figure 1-2). There are a total of 115 buildings, a bandstand, and a swimming pool on the property. The base property, situated at the mouth of the Red Butte Canyon, is adjoined on the north and west by the University of Utah, and on the east by the Wasatch Mountain range. Of the existing 119 acres, approximately 51 are to be excessed and transferred to the University.

1.4 CURRENT ACTIVITIES

The Fort currently serves as a base for the U.S. Army Support Detachment and is utilized by the National Guard and the Reserves for training. The primary mission of Fort Douglas is to provide administrative, logistical, maintenance, and family support services to active and reserve on-post units and off-post reserve units in Utah, Idaho, and Montana.

1.5 SITE HISTORY

Fort Douglas was established on October 26, 1862, to protect the Overland Mail and Telegraph lines from Indians and Mormons, according to site history. Boundaries established at that time included approximately 2,560 acres of land. Wooden buildings in the camp were replaced by stone buildings in the 1870s and the site was designated Fort Douglas, as opposed to Camp Douglas, at that time. A second major building program occurred at the site between 1904 and 1910.



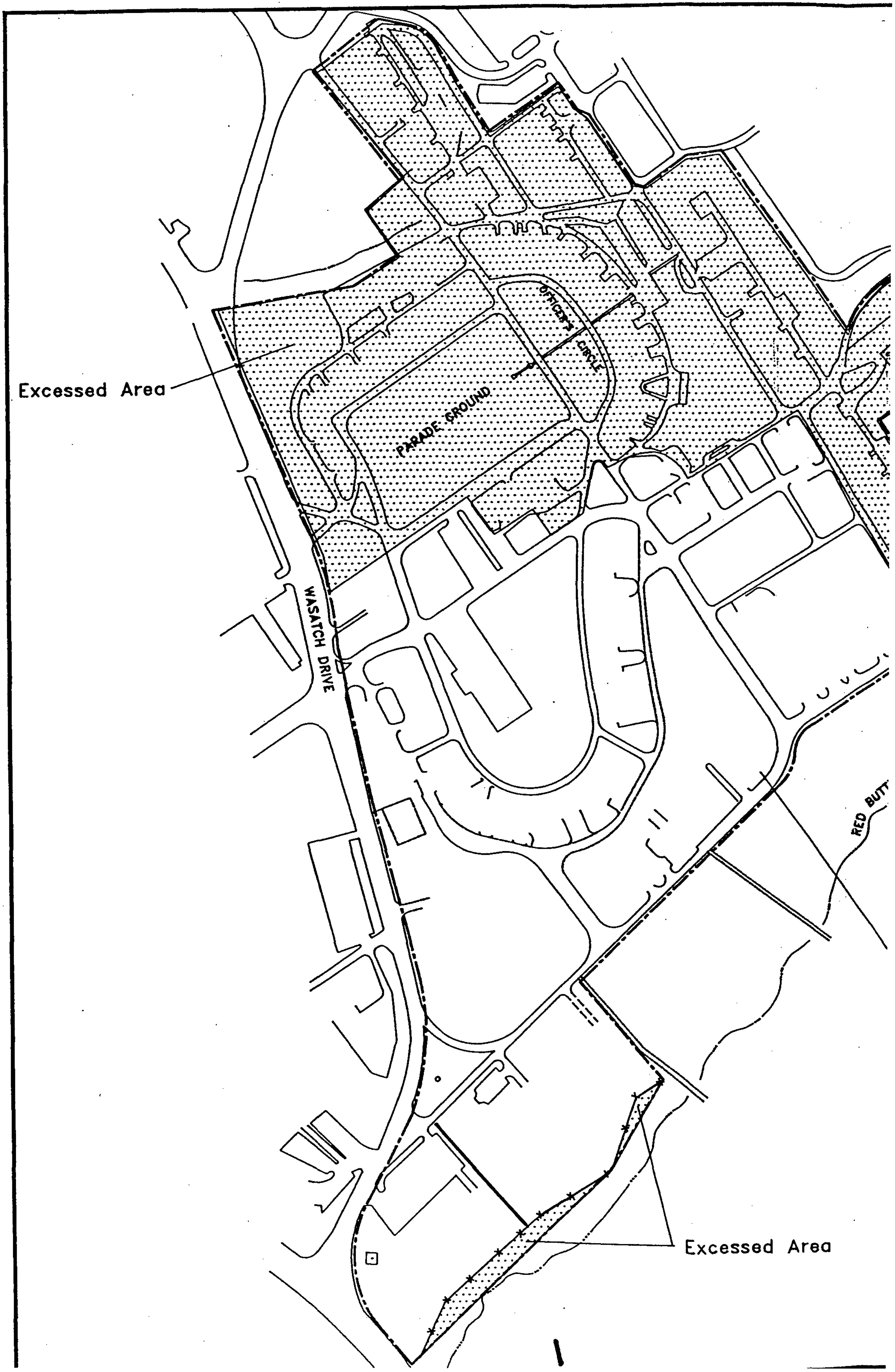
R.L. STOLLAR & ASSOCIATES INC.
Ground-Water Consultants

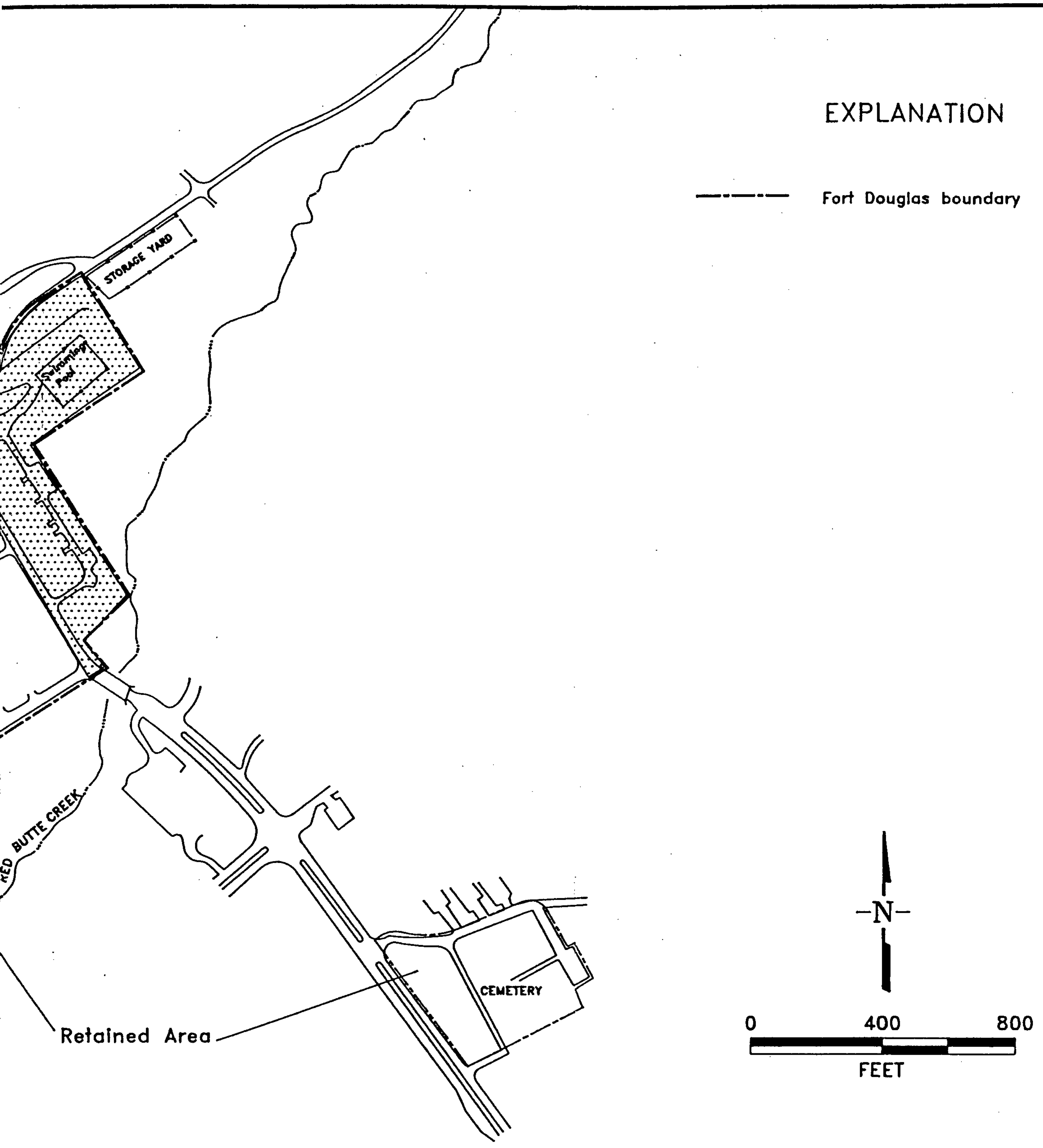
Fort Douglas
Location Map

Prepared for : U.S. Army Corps of Engineers
USATHAMA

Date: May, 1991

Figure 1-1


Excessed Area
OFFICER'S CIRCLE
PARADE GROUND
WASATCH DRIVE
RED BUTT
Excessed Area



R.L. STOLLAR & ASSOCIATES INC.
Ground-Water Consultants

Site Plan
Fort Douglas

Prepared for:
U.S. Army Corps of Engineers
USATHAMA

Date: August 1991

Figure 1–2

During World War I the camp was used as a prisoner-of-war facility for German prisoners. Following the war, the camp was nearly abandoned. No troops were left stationed at the post in 1921 and it was not until June 5, 1922 that the base was reopened because legislation proposing the abandonment of the site was not passed in a U.S. Congressional vote.

Additional building was begun in 1928 which included the construction of the Red Butte Dam. More construction was done in 1941, prior to involvement in World War II. When World War II ended, the activities at Fort Douglas were curtailed. Then in 1948, the U. S. Government decided that the base was not large enough to meet their needs and thus, much of the property was turned over to the War Assets Administration for disposal. By October 1949, the post included the buildings previously described, a 4-acre cemetery, and the Red Butte Reservoir, a total of approximately 7,300 acres. At this time, a total of approximately 150 people were stationed on the base.

During the Korean War, the base served as an induction center, and has increased in importance as a reserve and ROTC training center since that time.

Most of the buildings in the excessed area are included on the National Register of Historical Places. These buildings, for the most part, have always been used for housing and continue to be used for this purpose. The stone buildings on base were erected between 1874 and 1876 and are made out of sandstone quarried in the Red Butte Canyon.

Since May 1962, slightly less than 7,000 acres of the base land have been transferred to the U.S. Forest Service and the University of Utah's Research Park.

1.6 DESCRIPTION OF FACILITIES

Fort Douglas currently consists of approximately 119 acres of which approximately 68 acres will be retained by the Army. The portion of the property to be excessed and the facilities that will be investigated in this study include the following:

- Fort Douglas Military Museum;
- Thirty-nine family housing structures, three of which are used as administrative offices;

- A Chapel;
- An Officers Club;
- A NCO Club;
- A swimming pool with an associated water treatment building and bath house; and
- Three structures associated with a former service station.

A representative number of buildings were inspected during an initial site visit in March, 1991. Insulation on pipes in many of the buildings appears to be asbestos. For the most part, the insulation is in good condition and most damage has been repaired (taped, painted, etc.) to prevent unnecessary exposure of residents to the material. Because of the age of the buildings, asbestos in construction and insulation materials is expected to be widespread. The houses have all been maintained in excellent condition. Houses have been painted between occupants and when needed (approximately every 3 years). The possibility exists that lead paint was used in the past. Paint chips were observed in window sills in some of the buildings.

1.7 PROPERTY AND GROUNDS

Throughout the excessed area, there are pole-mounted transformers that may contain PCB-contaminated oils. Some are labeled indicating that they contain PCBs and many are not labeled. The transformers appear to be of varying ages, some are rusted while other appear relatively new. Poles on which the transformers are located have either one or three transformers per pole. The transformers are located approximately 30 feet from the ground and will be accessed with a manlift.

The Base Closure Final Environmental Impact Statement (FEIS) (Dames and Moore, 1991) indicates that three of the transformers at Fort Douglas were tested and contain 2 parts per million (ppm) PCBs, which is designated as "non-PCB" (40 CFR 761); however, the locations of these transformers is not known. One transformer was installed recently in the family camp area near the swimming pool, and documentation is available certifying that PCB-contaminant fluid was not used in the transformer. No testing has been done to confirm the presence of PCBs in the other transformers; they were labeled as containing PCBs in 1985 due to their age. There have been no reports of leakage from these transformers.

Two abandoned USTs, formerly used to store gasoline and waste oil, and a former vehicle wash rack and oil change/degreasing area are located in the vicinity of Building 39. Soil samples collected from five borings drilled in the area indicated lateral migration of contaminants from the tanks has not occurred. These samples were analyzed for benzene, ethylbenzene, toluene, and xylenes (BETX) and total petroleum hydrocarbons (TPH).

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The Project Manager is responsible for:

- making certain that personnel receive and are aware of the provisions of this plan, are instructed in the work practices necessary to ensure safety, and are familiar with planned procedures for dealing with emergencies;
- assuring the completion of Plan Acceptance Forms;
- approving any changes to the plan;
- making certain all field personnel are in compliance with the hazardous waste worker health and safety training and medical surveillance requirements of 29 CFR 1910.120;
- assuring compliance with all other applicable regulations;
- making certain that personnel are aware of the potential hazards associated with site operations;
- obtaining permission for site access and coordinating activities with appropriate personnel;
- coordinating power outages with appropriate site personnel;
- correcting any work practices or conditions that may result in injury or exposure to hazardous substances; and,
- preparing any accident and routine job exposure forms (Appendix A - Accident Report and Exposure History Forms).

2.2 SITE SAFETY OFFICER

The Site Safety Officer (SSO) is responsible for:

- implementing the project HASP and reporting to the Safety Coordinator and the Project Manager if there are any deviations from the anticipated conditions described in the plan;
- stopping work at any time if warranted due to unsafe conditions;
- conducting periodic inspections to determine if the HASP is being followed;
- monitoring on-site hazards and conditions;
- calibrating all monitoring equipment on a daily basis and recording results on the appropriate forms (Appendix A - Instrumentation Calibration Check and Environmental Monitoring Sheets);
- making certain that all monitoring equipment is operating correctly and is maintained according to manufacturer's instructions;
- selecting protective clothing and equipment;
- periodically inspecting protective clothing and equipment;
- ensuring that protective clothing and equipment are properly stored and maintained;
- assuring proper health and safety training of field staff;
- defining limited access zones on a daily basis;
- monitoring on-site project personnel for signs of stress, such as cold exposure, heat stress, and fatigue;
- coordinating emergency care, evaluation, rescue, etc.;

- enforcing the "buddy" system; and

- enforcing the requirements of the HASP on-site.

2.3 PROJECT PERSONNEL

Project personnel that may be on-site during all or part of the remedial investigation include the USATHAMA Contracting Officer's Representative, Project Manager, Site Safety Officer, field staff, subcontractors, and Fort Douglas contacts. Project personnel responsibilities include:

- complying with the HASP;

- taking all reasonable precautions to prevent injury to themselves and to their fellow employees;

- performing only those tasks that they believe they can do safely, and immediately reporting any accidents and/or unsafe conditions to the Site Safety Officer; and,

- notifying the Project Manager and Site Safety Officer of any special medical problems (e.g., allergies) and making certain that all on-site personnel are aware of any such problems.

3.0 SAFETY AND HEALTH HAZARD ANALYSIS

A task-specific safety and health analysis, including the potential contaminants follows.

3.1 ASBESTOS SAMPLING

The hazards associated with asbestos sampling include:

1. Exposure to asbestos

   The probability of an unacceptable exposure to airborne asbestos fibers during the collection of bulk samples is extremely low providing the sampling techniques described in this plan are utilized (Section 4.6). The engineering controls implemented during the sampling process have proven effective in preventing significant exposures to workers and/or residents in previous years of sampling conducted by the author. By wetting surface materials with surfactant prior to and during sample collection, particles are not released to the air. Sample locations are patched or plugged to prevent friable edges from being a source of an airborne release.

2. Potential insect and snake exposure (spiders, snakes, etc. living in the buildings to be inspected).

   There is the potential for encountering insects, snakes, and rodents in crawl spaces and abandoned buildings. The basic precautions described in this plan should allow a significant reduction in risk of bites and scratches.

3.2 LEAD-BASED PAINT SAMPLING

The hazards associated with lead-based paint sampling include:

1. Minimal exposure to lead dust

   The risk of worker or resident exposure to lead ingestion or inhalation during dry paint sampling is extremely low providing the sampling technique described in this plan is utilized. Paint contains a binder solution which reduces the fragmentation of the product in a dry state. Therefore, airborne release of paint particles is minimal. Simple hygiene procedures shall prevent ingestion of residual lead. Inorganic lead is not absorbed through the skin.

3.3 PCB SAMPLING

The hazards associated with PCB sampling include:

1. Skin and inhalation exposure to PCBs in the transformers

   PCBs may be absorbed through the skin, particularly in the presence of a fat soluble solvent. The PCBs to be sampled for at Fort Douglas are in transformers containing diabetic fluids which are typically not significantly absorbed through the skin. However, PCBs may cause skin disorders following extensive direct contact. Skin contact and/or absorption may be effectively prevented through the use of the chemical protective clothing prescribed in this plan.

   PCB ingestion is easily prevented through simple personal hygiene practices and use of chemical protective clothing. The oil based material is very visible on clothing or other products and therefore easily avoided.

   The inhalation of PCB vapors or mist is a potential concern during the initial opening of the transformer caps due to the hot, enclosed conditions which exist. Respiratory protection against both the particulate and vapor phase exposures is warranted.

2. Contact with high-voltage overhead power lines

   A risk of electrocution and falls do exist during the transformer sampling task. These risks shall be mitigated through the use of proper equipment and professional electricians as described in the controls section.

3. Instability of manlift required to reach the transformers.

   The manufacturer's standard operating procedures for operating the manlift will be strictly followed.

3.4 DRILLING AND SOIL SAMPLING OPERATIONS

The hazards associated with drilling and soil sampling operations include:

1. Inhalation and skin exposure to contaminants in the soil, primarily total petroleum hydrocarbons including benzene, toluene, ethylbenzene, xylene, and tetraethyl lead, and volatile chlorinated hydrocarbons associated with the degreasing operations performed at Building 39, are possible. It is unknown what contaminants may be associated downgradient of the University of Utah storage area. Personal protective clothing and air monitoring will be utilized to prevent exposures.

2. Potential exposure to flammable and/or combustible vapors emanating from the possible soil contaminants listed above.

   A combustible gas indicator will be used during all drilling operations. The potential for explosion is high when drilling in landfills, due to the presence of methane, and in soils heavily contaminated with petroleum products, due to their inherent properties, however, based on site records, neither situation is expected at this site. Monitoring protocols and action levels are included in Section 8.0.

3. Mechanical hazards associated with the operation of drilling equipment, including unguarded machinery, equipment rollover, contact with moving equipment, and flying debris from the borehole.

   Only trained and experienced personnel will be allowed into the exclusion zone, therefore minimizing the potential for injuries associated with mechanical equipment. In addition, the drilling operations will be closely monitored to ensure that problems are noted immediately and corrected.

4. Physical hazards associated with the operation of drilling equipment such as back strain from improper lifting of heavy equipment; heat stress; biological hazards such as insect bites and stings, snake bites, and contact with mammals; contact with overhead and underground power lines; and noise exposure.

   Safety briefing will be held daily to remind site personnel of potential physical hazards.

5. Working outdoors in adverse weather conditions such as thunderstorms, tornados, and flash floods.

This health and safety plan will address the hazards listed above and ways personnel will be protected from them.

4.0 CHEMICAL HAZARD ASSESSMENT

4.1 INTRODUCTION AND BACKGROUND

Potential toxic and hazardous material problems existing in the excessed area include asbestos, radon, PCBs, volatile organic carbons, and lead. Radon sampling was completed prior to this investigation and is therefore not addressed in this report. However, preliminary results indicate that radon is present in at least some of the buildings. Radon occurs as a natural radioactive decay product in soils and will accumulate in improperly ventilated areas. Preliminary studies indicate that the highest short term detector reading was 4 picocuries/liter and the average reading of the short term detectors was 1 picocurie/liter. The U.S. Environmental Protection Agency (EPA)-suggested average long term exposure limit for radon in homes is 4 picocuries/liter. Additional testing has been completed since this initial study; however, results were not available for this report.

As stated in the FEIS, "Asbestos or asbestos-containing materials (ACMs) are suspected to be present in every building in the excessed area as part of the construction materials commonly used during the early periods that Fort Douglas was built." The Enhanced Preliminary Assessment (PA) (Weston, 1989) stated that asbestos sampling had been done in seven buildings located throughout Fort Douglas. Four of the seven buildings (8, 15A, 18C, and 32) are located in the excessed area. Asbestos was found in the lagging material of pipes in all four buildings. The PA also indicated that asbestos insulation is suspected on the hot water pipes in Building 54 (the NCO Club), Building 49 (the Officer's Club), and Building 350 (the swimming pool bath house). Asbestos siding may also be present on the Chapel and several buildings may have shingles which contain asbestos.

The PA also identified pole-mounted transformers which potentially contain PCBs in 14 locations in the excessed area. The transformers are owned by the Army and range in condition from rusted to good. Reportedly, three transformers have been sampled and showed PCB levels of 2 ppm. Eight transformers were labeled as containing PCBs in 1985 due to their age.

Soil sampling and potentially ground-water monitoring well installation and ground-water sampling will be performed near two possible sources of contamination: the storage yard located off Fort Douglas property at the University of Utah, and the two underground storage tanks (USTs) located adjacent to Building 39, which has been added to the original area of the property planned to be excessed. Contamination associated with the storage yard has not been positively identified; however, some transformers which had been tested for PCBs but not labeled as containing PCBs were in evidence as well as three drums labeled as radioactive waste and listing a University of Utah safety services employee's name. There was no visible evidence of spills, leaks, or discolored soil. Building 39 was historically operated as a service and maintenance station for gasoline-powered vehicles. Later, the area was used as a vehicle wash rack and oil change/degreasing area. The USTs contained gasoline and waste oil. Soil samples taken in the area did not detect the presence of any petroleum contaminants (TPH, BETX).

4.2 ASBESTOS

Asbestos or asbestos containing materials (ACMs) may be present in every building in the area to be excessed. These buildings include but are not limited to: the Fort Douglas Military Museum, 36 family housing structures which contain 61 housing units, three family housing structures used as administrative offices, a chapel, an officers club, an NCO club, three structures associated with the former service station, a swimming pool with an associated water treatment building and bath house. The comprehensive asbestos sampling plan for the excessed property shall be conducted by certified asbestos building inspectors only.

4.2.1 CHARACTERISTICS

Asbestos is the name of a class of magnesium-silicate minerals that occur in fibrous form. Asbestos minerals are divided into two groups: serpentine and amphibole. The distinction between groups is based upon its crystalline structure. Serpentine minerals have a sheet or layered structure, where amphiboles have a chain-like crystal structure.

Chrysotile is the only mineral in the serpentine group. Chrysotile is the most commonly used type of asbestos accounting for approximately 95 percent of the asbestos found in buildings in the United States. Chrysotile is commonly known as "white asbestos", so named for its natural color.

Five types of asbestos are found in the amphibole group. Amosite, the second most likely type of asbestos to be found in buildings, is referred to as "brown asbestos", so named for its natural color. Crocidolite, or "blue asbestos", is utilized in high temperature insulation applications. The remaining three types of asbestos in the amphibole group are: anthrophyllite, tremolite, and actinolite. These types are extremely rare and of little commercial value. Occasionally they are found as contaminants in asbestos-containing materials.

ACM in buildings is found in three forms: 1) sprayed or trowelled on ceilings and walls (surfacing materials); 2) in insulation around hot or cold pipes, ducts, boilers, and tanks (pipe and boiler insulation); and 3) in a variety of buildings products such as ceiling and floor tiles and wall boards (miscellaneous materials). In general, ACM in the first two categories is of the greatest concern. The potential for a product containing asbestos to release breathable fibers depends on its degree of friability. Friable means that the material can be crumbled with hand pressure and is therefore likely to emit fibers. The fibrous or fluffy sprayed on materials used for fire-proofing, insulation, or sound proofing are considered to be friable. Materials such as vinyl-asbestos floor tile or roofing felts are considered nonfriable and generally do not emit airborne fibers unless subjected to sanding or sawing operations. Asbestos-cement pipe or sheet can emit airborne fibers if the materials are cut or sawed, or if they are broken during demolition operations, pipe repair work, renovation, or other activities.

4.2.2 HEALTH HAZARD DATA

The relationship between asbestos exposure levels and health risk is complex. The potential for disease appears to be related to the physical and chemical characteristics of asbestos fibers as well as to the concentration of fibers in the air. Inhalation of tremolite, anthrophyllite, and actinolite has been shown to cause increased incidence of lung cancer and mesothelioma of the pleura and peritoneum (chest cavity and abdominal lining, respectively), and asbestosis. Asbestosis is a disabling fibrotic lung disease that is caused only by asbestos exposure. Repeated or prolonged ingestion may be involved in cancers of the buccal cavity (mouth), pharynx, esophagus, stomach, colon, and rectum (Appendix B). As with other known chronic occupational diseases, symptoms of disease associated with asbestos generally do not appear for 20 years after initial exposure.

Epidemiological studies indicate that the risk of lung cancer among exposed workers who smoke cigarettes is greatly increased over the risk of lung cancer among nonexposed smokers and exposed nonsmokers. These studies suggest that cessation of smoking will reduce the risk of lung cancer for a person exposed to asbestos but will not reduce it to the same level of risk as that existing for an exposed worker who has never smoked.

4.3 VOLATILE ORGANIC CARBONS

Volatile organic carbons represent a broad category of carbon-based chemicals that have high vapor pressures, which allow them to evaporate readily. These chemicals may be of concern when performing the soil and ground-water sampling.

The specific chemicals that may be encountered include TPH, BETX, and chlorinated hydrocarbons. TPH and BETX are associated with fuel-type products such as gasoline, and the chlorinated hydrocarbons are associated usually with degreasing procedures.

4.3.1 HEALTH HAZARD INFORMATION

Petroleum distillate fuels are mixtures of aliphatic and aromatic hydrocarbons. The predominant classes of compounds in high flammability fuels, such as gasoline and diesel fuel are the paraffins (e.g., hexane, octane), naphthalene and volatile aromatics (e.g., benzene, toluene). Table 4 lists the primary constituents of gasoline.

The major gasoline hydrocarbons of concern, in terms of risk to human health, are the aromatic compounds benzene, toluene, ethylbenzene, and xylene.

Chemicals are usually added to automotive and aviation fuels. They serve as anti-knock agents, anti-oxidants, sweetening inhibitors, metal deactivators, corrosion inhibitors, deicing and anti-stall agents, pre-ignition preventers, dyes and upper cylinder lubricants. These additives include metal-organic compounds (lead and manganese), phosphates (cresyl and alkylamine), halogenates (chlorinates and bromates), amines, alcohols, phenols and acids (carboxylic, phosphoric and sulfonic). Specific additives and their percentages in fuels varies geographically and seasonally.

Petroleum distillate fuels exhibit relatively low acute inhalation and dermal toxicity. Concentrations of 160 to 270 ppm gasoline vapor have been reported to cause eye, nose, and throat irritation after several hours of exposure. Levels of 500 to 900 ppm can cause irritation and dizziness in one hour, and 2000 ppm produces mild anesthesia in 30 minutes. Some workers involved in tank removal operations have reported headaches when exposed to 25 ppm or more of gasoline vapors measured with a photoionization meter. Most fuels, particularly gasoline, kerosene, and jet fuels, are capable of causing skin irritation after several hours of contact with the skin. In addition, kidney and liver damage has been observed in laboratory animals exposed to 292 ppm of unleaded gasoline (54 FR 2424).

Petroleum fuels exhibit moderate oral toxicity. The lethal dose of gasoline in children has been reported to be as low as 10-15 grams (2-3 teaspoons). In adults, ingestion of 20-50 grams of gasoline may produce severe symptoms of poisoning. If liquid fuel is aspirated (passed into the lungs), gasoline and other petroleum distillate fuels may cause secondary pneumonia.

Recently OSHA established an 8 hour TWA of 300 ppm and a STEL of 500 ppm (54 FR 2424), for gasoline, and the ACGIH has established a threshold limit value of 300 ppm for gasoline. The limit took into consideration the average concentration of benzene in gasoline (1 percent) as well as its common additives. Exposure limits established by other countries range from 250 to 500 ppm. Chemical data sheets, prepared for the U.S. Coast Guard's Chemical Hazard Information System (CHRIS) list 200 ppm as the permissible exposure limit for kerosene and jet fuels. This limit was not developed by NIOSH/OSHA or ACGIH.

Benzene may cause adverse health effects via inhalation, ingestion, skin or eye contact. Exposure to benzene can cause central nervous system depression and cardiac sensitization. Chronic exposure to benzene has produced anorexia, aplastic anemia and leukemia. Benzene is considered a human carcinogen by OSHA (Appendix B).

Ethylbenzene may cause adverse health effects via inhalation, ingestion, skin or eye contact. Exposure to ethylbenzene can cause corneal injury, skin irritation and blistering, dizziness, and depression (Appendix B).

Toluene may cause adverse health effects via inhalation, ingestion, skin contact and absorption, and eye contact. Exposure to toluene can cause fatigue, dizziness, skin numbness or a "pins and needles" feeling (Appendix B).

Xylene may cause adverse health effects via inhalation, ingestion, skin contact or absorption, and eye contact. Exposure to high concentrations of xylene can cause breathing difficulties, dizziness, drowsiness and unconsciousness (Appendix B).

The volatile chlorinated hydrocarbons most commonly used for degreasing procedures include the dichloroethanes, methylene chloride, 1,1,2,2-tetrachloroethane, and the trichloroethanes.

The dichloroethanes (1,1-dichloroethane and 1,2-dichloroethane) may cause adverse health effects via inhalation, ingestion, skin and eye contact. Breathing the dichloroethanes may cause drowsiness and unconsciousness as well as possible liver, kidney and lung damage (Appendix B).

Methylene chloride may cause adverse health effects via inhalation, ingestion, skin or eye contact. exposure to methylene chloride can cause light-headedness, nausea, vomiting, headache, unconsciousness and death (Appendix B).

1,1,2,2-Tetrachloroethane may cause adverse health effects via inhalation, ingestion, skin contact or absorption, and eye contact. Exposure to 1,1,2,2-tetrachloroethane can cause irritation of the eyes and nose, drowsiness, nausea, and vomiting, as well as liver and kidney damage (Appendix B).

The trichloroethanes (1,1,1-trichloroethane and 1,1,2-trichloroethane) may cause adverse health effects via inhalation, ingestion, skin contact or absorption, and eye contact. Exposure to the trichloroethanes can cause drowsiness, incoordination, unconsciousness and death (Appendix B).

4.4 LEAD

The PA indicates the possibility for painted surfaces at Fort Douglas to contain lead. Accordingly, samples of painted surfaces and wipe samples will be taken to determine the presence or absence of lead in the paint. In addition, soil and water sampling near the USTs at Building 39 may expose workers to leaded gasoline (tetraethyl lead), because one of the USTs was presumed to contain leaded gasoline.

4.4.1 HEALTH HAZARD DATA

It is unlikely that large enough quantities of lead dust will be disturbed to cause acute exposures. However, because lead accumulates in the body and causes poisoning over time (it is a cumulative poison), it will be desirable to keep inhalation of lead dust to a minimum. The symptoms of lead poisoning include: anemia, neuropathy, loss of appetite, constipation, metallic taste in the mouth, weakness, insomnia, headache, muscle and joint aches, and in some cases, weakness in extensor muscles (known as "wrist drop" or "foot drop"). The target organs for lead in the body include the skeletal system, the nervous system, and the red blood cells (Appendix B).

Tetraethyl lead (TEL) may also enter the body through ingestion or inhalation. In addition, it is readily absorbed through the skin. If a large degree of absorption has occurred from inhalation or skin contact, insomnia, excitability, delirium, coma or even death may result. Exposure of the skin to TEL may result in burning (Appendix B).

Table 4-1 Hazardous Characteristics of Constituents Believed to be On-Site

ASBESTOS

CAS #: 1332-21-4

PEL	IDLH	IP	VP
0.2 fiber/cc 0.1 fiber/cc (proposed)	None Established	--	--

ROUTES OF ENTRY:	Inhalation, ingestion, and skin contact.
ACUTE EFFECTS:	Ingestion may cause gastrointestinal irritation, dermatitis, and conjunctivitis.
CHRONIC EFFECTS:	Human carcinogen. Known to cause asbestosis (interstitial fibrosis of lung tissue), lung cancer, and mesothelioma of the pleura or peritoneum. Repeated or prolonged ingestion may be involved in cancers of the buccal cavity and pharynx, esophagus, stomach, colon and rectum. There is a strong synergistic relationship between susceptibility to lung cancer and smokers exposed to asbestos.

POLYCHLORINATED BIPHENYL (CHLORODIPHENYL - 54% CHLORINE)

CAS #: 11097-69-1

PEL	IDLH	IP	VP
0.5 mg/m^3 (skin)	5 mg/m^3	--	6 E-5

ROUTES OF ENTRY:	Primarily skin, eye, and mucous membrane contact, either directly or <u>via</u> airborne contamination. Also enters <u>via</u> inhalation, absorption, and ingestion.
ACUTE EFFECTS:	Eye irritation. Acne-form dermatitis.
CHRONIC EFFECTS:	Carcinogen, liver damage.

LEAD

CAS #: 7439-92-1

PEL	IDLH	IP	VP
0.050mg/m^3	700 mg/m^3	N/A	0 mm Mercury (Hg)

ROUTES OF ENTRY: Inhalation, ingestion, contact

ACUTE EFFECTS: Weakness, facial pallor, abdominal pain, irritated eyes.

CHRONIC EFFECTS: Anemia, loss of appetite, weakness in extensor muscles ("wrist drop", "foot drop"), headache, metallic taste in mouth.

BENZENE

CAS #: 71-43-2

PEL	IDLH	IP	VP
1 ppm	CA*	9.25 eV	75 mmHg

ROUTES OF ENTRY: Inhalation, ingestion, skin absorption, skin & eye contact.

ACUTE EFFECTS: Irritates eyes and nose, headaches, nausea, fatigue, abdominal pain, dermatitis, and depression.

CHRONIC EFFECTS: Carcinogen, central nervous system damage, and blood disorders.

ETHYL BENZENE

CAS #: 100-4-4

PEL	IDLH	IP	VP
100 ppm	2000 ppm	8.76 eV	71 mmHg

ROUTES OF ENTRY: Inhalation, ingestion, and skin & eye contact.

ACUTE EFFECTS: Irritated eyes and mucous membranes, headaches, narcosis, coma.

CHRONIC EFFECTS: CENTRAL NERVOUS SYSTEM DAMAGE.

XYLENE

CAS #: 1330-20-7

PEL	IDLH	IP	VP
100 ppm	1000 ppm	8.56 eV	7 mmHg

ROUTES OF ENTRY: Inhalation, skin absorption, ingestion, skin & eye contact.

ACUTE EFFECTS: Irritated eyes, nose, and throat. Corneal vacuolization, nausea, dizziness, and abdominal pain.

CHRONIC EFFECTS: Blood and central nervous system effects, kidney, and liver dysfunctions.

*CA - NIOSH recommends treating as a potential carcinogen.

TOLUENE

CAS #: 108-88-3

PEL	IDLH	IP	VP
100 ppm	2000 ppm	8.8 eV	22 mmHg

ROUTES OF ENTRY: Inhalation, skin absorption, ingestion, skin & eye contact.

ACUTE EFFECTS: Fatigue, confusion, dizziness, headaches, dermatitis, dilated pupils, nervousness, and insomnia.

CHRONIC EFFECTS: Central nervous system damage, liver, and kidney disorders.

NAPHTHALENE

CAS #: 91-20-3

PEL	IDLH	IP	VP
10 ppm	500 ppm	8.14 eV	--

ROUTES OF ENTRY: Inhalation, ingestion, eye & skin contact, skin absorption.

ACUTE EFFECTS: Eye irritation, headache, nausea, abdominal pain, profuse sweating, jaundice.

CHRONIC EFFECTS: Hemolysis, liver & kidney damage, bladder irritation, anemia.

PHENOL

CAS #: 108-95-2

PEL	IDLH	IP	VP
5 ppm	100 ppm	8.5 eV	0.35 mmHg

ROUTES OF ENTRY: Inhalation, skin absorption, ingestion, eye & skin contact.

ACUTE EFFECTS: Weakness, muscle aches, pain, dark urine, anorexia, skin bumps, dermatitis.

CHRONIC EFFECTS: Liver & kidney damage.

COAL TAR PITCH VOLATILES
(Polynuclear Aromatic Hydrocarbons)

CAS #: 65996-93-2

PEL	IDLH	IP	VP
0.2 mg/m^3	40 mg/m^3	NA	NA

ROUTES OF ENTRY: Inhalation, skin absorption, ingestion, skin & eye contact

ACUTE EFFECTS: Eye and respiratory irritation. Smarting/burning of skin

CHRONIC EFFECTS: Insomnia, delirium.

TETRAETHYL LEAD

CAS #: 78-00-2

PEL	IDLH	IP	VP
0.075 mg/m^3 (skin)	40mg/m^3	11.10 eV	0.2 mmHg

ROUTES OF ENTRY: Inhalation, ingestion, skin absorption, skin & eye contact

ACUTE EFFECTS: Insomnia, lassitude, anxiety, tremors, pallor, nausea, eye irritation.

CHRONIC EFFECTS: Anorexia, disorientation, hallucinations, psychosis, mania, convulsions, coma.

1,1-DICHLOROETHANE

CAS #: 75-34-3

PEL	IDLH	IP	VP
100 ppm	4000 ppm	--	182 mmHg

ROUTES OF ENTRY: Inhalation, ingestion, skin or eye contact.

ACUTE EFFECTS: Breathing the chemical may cause drowsiness or unconsciousness. It may also damage the liver, kidneys, and lungs.

CHRONIC EFFECTS: Prolonged, confined, or repeated skin contact can produce a slight burn.

METHYLENE CHLORIDE

CAS #: 75-09-2

PEL	IDLH	IP	VP
500 ppm	CA*	10.81 eV	476 mmHg

ROUTES OF ENTRY: Inhalation, ingestion, skin or eye contact.

ACUTE EFFECTS: Methylene chloride is an anaesthetic. Inhalation may cause mental confusion, light-headedness nausea, vomiting, and headache. May also irritate the eyes, skin, and respiratory tract. Exposure to this chemical may worsen angina.

CHRONIC EFFECTS: Prolonged or repeated skin exposure may cause irritation.

1,1,2,2-TETRACHLOROETHANE

CAS #: 79-34-5

PEL	IDLH	IP	VP
1 ppm 7 mg/m^3 (skin)	CA*	11.1 eV	8 mmHg

ROUTES OF ENTRY: Inhalation, ingestion, skin contact or absorption, and eye contact.

ACUTE EFFECTS: Inhalation of high concentrations may irritate the eyes and nose, cause nausea, vomiting and drowsiness. Severe exposure may cause a dusky discoloration of the skin, followed by unconsciousness and death.

CHRONIC EFFECTS: Prolonged or repeated exposure either through inhalation or skin absorption may cause fatigue, tremors, weight loss, heart, liver, and kidney damage, vomiting, and yellow jaundice.

1,1,2-TRICHLOROETHANE

CAS #: 79-00-5

PEL	IDLH	IP	VP
10 ppm	CA*	--	19 mmHg
45 mg/m^3 (skin)			

ROUTES OF ENTRY:	Inhalation, ingestion, skin contact or absorption, and eye contact.
ACUTE EFFECTS:	Irritation of the eyes and nose, drowsiness, incoordination, unconsciousness, and death. It may also cause liver and kidney damage.
CHRONIC EFFECTS:	Repeated or prolonged exposure may cause liver or kidney damage.

---

*CA - NIOSH recommends treating as a potential carcinogen.
PEL - permissible exposure limit
IDLH - Immediately dangerous to life and health
IP - Ionization potential
VP - Vapor pressure

Table 4-2 Primary Constituents of Gasoline

Hydrocarbon Type	Volume	Number of Major Constituents	Solubility Range Range (mg/l)
Isoparaffins (alkanes)	46.55	7	0.001 - 50.0
Alkylbenzenes (aromatics)	26.08	8	40.0 - 1700.0
n-paraffins (alkanes)	11.40	3	9.5 - 62.0
Mono-olefins (alkenes)	8.96	8	78.0 - 430.0
Naphthalene (aromatics)	4.68	5	7.0 - 160.0

4.5 POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls (PCBs) is a common name for a class of halogenated cyclic hydrocarbons. Commercial PCBs are generally mixtures of many different chlorinated biphenyls, with the amount of chlorine present determined according to specific operational needs. The approximate chlorine content of PCB mixtures is as follows: Arochlor, 1221 (21 percent), 1016 (42 percent), 1242 (42 percent), 1254 (54 percent), 1260 (60 percent); Kanechlors, 300 (43 percent), 400 (48 percent), and 500 (53 percent). PCBs are used extensively in capacitors and transformers. They are also found in the manufacture of plasticizers, hydraulic fluids, lubricants, surface coatings, inks, sealants, adhesives, and pesticide extenders.

Physically, PCBs are thermally stable, very resistant to degradation, and resistant to oxidation, acids, bases and other chemical agents. PCBs are soluble in most organic solvents and lipids, but only slightly soluble in water, glycerol, and glycols. PCBs in transformers are generally mixed with oils and due to their specific density they will sink to the bottom of the transformer.

4.5.1 HEALTH HAZARD INFORMATION

Chemical toxicity of PCBs varies with the amount of chlorine present in the structure. Routes of exposures for PCBs are ingestion, inhalation, and dermal contact. Dermal contact exposures are the most prominent in past occupational experiences. Effects of dermal exposures result in an acne like skin irritation which will persist with continued exposure. Acute effects of PCB exposure are: chloracne; distinctive hair follicles; eye discharges; swelling of the upper eyelids and hyperemia of the conjunctiva; hyperpigmentation of skin, nails, and mucous membrane; fever; hearing difficulties; limb spasms; headache; vomiting; and diarrhea. Chronic effects result in liver damage and yellow jaundice. PCBs are also a suspect human carcinogen (Appendix B).

4.6 HEALTH HAZARD EVALUATION

Tasks included in the scope-of-work for the Fort Douglas EI/AA require minimal disturbance of toxic and hazardous materials. To prevent asbestos exposures, all sample areas will be wetted. In addition, respirators with high efficiency particulate air (HEPA) filters will be utilized and latex gloves and Tyvek suits will be worn to minimize exposure to the hazardous materials. The most significant routes of entry for these contaminants are inhalation and ingestion. Inhalation will be minimized by the use of personal protective equipment as discussed above and ingestion will be avoided by requiring all site workers to utilize good hygiene practices. These will include washing hands and face before eating, drinking, or smoking; not smoking near the sampling areas; and decontaminating personnel and equipment to ensure contaminants are not carried off-site.

PCBs have very low vapor pressures and thus are primarily a concern when contacted with the skin. Skin contact will be avoided by ensuring that anyone handling the sampled liquids wear gloves that are resistant to PCBs. Neoprene or Viton gloves will be used for tasks involving the handling of PCBs. Both are rated for greater than 8 hours use. Transformer sampling will be done by an electrical journeyman and an apprentice licensed in the State of Utah. Stollar field personnel will oversee the sampling tasks and will only have to handle the sampled material when packaging the samples for transport.

Because the sampling procedures for the lead-based paint do not require invasive tactics, the health hazards associated with the sampling are low. Care will be taken to ensure that a minimum of dust will be disturbed during sampling. In addition, because no petroleum hydrocarbons have been detected in preliminary soil sampling, the health hazards associated with possible tetraethyl lead exposure are also low. Drilling operations will be monitored for organic vapor concentrations and flammable vapor levels to ensure adequate respiratory protection is utilized during the tasks and to avoid the possibility of explosions. Personal protective equipment (PPE) will be utilized to prevent exposure to potential contaminants. Section 13 addresses levels of protection and action levels requiring the use of PPE.

5.0 PHYSICAL HAZARD ASSESSMENT

Physical hazards of concern include:

- adverse weather conditions;
- falling, tripping, or slipping;
- flammable materials;
- moving machinery;
- noise;
- exposed energized overhead power lines; and
- nonionizing radiation (sunlight).

5.1 ADVERSE WEATHER CONDITIONS

In the event of rain, snow, or other inclement weather, conditions will be assessed on site to determine if field operations can proceed safely. If it is determined that the weather poses a significant additional hazard, site operations will be stopped and rescheduled. Some of the items to be considered prior to determining if work should continue are:

- potential for cold stress and cold-related injuries;
- potential for heat stress and heat-related injuries;
- treacherous weather-related working conditions;
- high winds;
- limited visibility;

- potential for electrical storms/flash flooding; and

- tornado watch or warning.

5.1.1 HEAT AND COLD STRESS

If temperatures at the site exceed 75°F, site personnel wearing level C or greater personal protective equipment will be evaluated for heat stress by monitoring heart rates and/or the ambient temperature. Work/rest periods will be adjusted according to the requirements of the "Threshold Limit Values and Biological Exposure Indices" (latest edition, American Conference of Governmental Industrial Hygienists) taking into account the effects of personal protective equipment (PPE) in use. The action level temperature for mandatory heat stress monitoring of personnel in level D PPE is 85°F. Sufficient cool water is to be provided. Engineering controls such as solar shielding will also be utilized as appropriate. See Appendix C for a description of heat stress monitoring and control.

Cold stress disorders such as hypothermia shall be monitored for during inclement weather conditions such as rain, sleet, and snow. Hypothermia often occurs between temperatures of 30 and 50°F, which are temperatures most people believe not to be dangerous. At ambient and wind chill temperatures below 0°F, frostbite is also a major concern for personnel working in the field. Appendix D provides more detailed information on the procedures and precautions to take regarding cold stress conditions.

5.1.2 ELECTRICAL STORMS

The field team must be aware that thunder and lightning storms are possible. Approaching storms will be cause for work to cease until they no longer pose a hazard. Flash flooding is a possibility along Red Butte Creek. Peak flows occur in late April and May as a consequence of snow melting. Flash flooding in the work zone or adjacent areas can cause ingress/egress problems. Cease operations and seek shelter as necessary.

5.1.3 TORNADOS

Tornados are not common in the Salt Lake City area; however, the possibility does exist in the spring and summer months. The existence of tornado watch and warning alerts should be monitored via the local news broadcasts. A safe place to seek refuge should be established with the base commander once on site. In the event that the threat of a tornado exists, work shall cease and all personnel shall proceed to the designated shelter.

5.2 GENERAL SITE SAFETY

The work site shall be maintained in a safe condition, free of clutter, tripping hazards, etc. at all times. It is each person's responsibility to maintain a safe work site at all times. Noted infractions will be corrected immediately. Ground surface irregularities such as ditches, pits, and animal burrows that could pose a hazard in the work area shall be marked with stakes, barrier tape, cones, or other suitable warning device.

5.3 EQUIPMENT OPERATION

Only thoroughly trained, licensed, and qualified operators are allowed to operate the drilling rig, manlift, and other heavy equipment. Transformers will be opened and sampled by a trained, licensed electrical journeymen and his/her apprentice.

5.4 EQUIPMENT SURVEYING

Prior to demobilization, tools and equipment will be surveyed with a photoionization detector (PID) or flame ionization detector (FID) to identify contamination and all tools and equipment will be decontaminated, regardless of whether a reading occurs with the PID or FID. In addition, where airborne dust contamination is a potential, a wipe sample may be collected from the equipment and analyzed to identify contamination, based on the SSO's assessment.

5.5 MATERIAL HANDLING

During well drilling and well development activities, heavy material and equipment may need to be moved, creating the potential for sprain or strain injuries. Powdered substances, such as silica sand, bentonite, and concrete can be inhalation hazards. In addition, grout, concrete, or other chemical substances may irritate, burn, or be absorbed by the skin. These hazards can be alleviated by using a rig to move or place heavy equipment, utilizing respirators, and wearing impermeable gloves and clothing.

5.6 FLAMMABILITY

Fuels and other flammable materials brought on site shall be kept in approved containers and clearly labeled in accordance with applicable regulatory requirements. Appropriate fire extinguishers will be kept on site at all times (one 10 lb ABC extinguisher will be kept in each truck) for use in areas where flammability hazards exist.

5.7 OVERHEAD/UNDERGROUND POWERLINES

The positioning or operation of drilling equipment or truck cranes in the vicinity of utility services will not be initiated until the activities have been coordinated with the Fort Douglas Commander's Representative, Gary Silvers. Operation of equipment adjacent to or under overhead power lines in such a manner that encroaches on authorized clearances is not allowed unless one of the following are satisfied:

- Power has been shut off and positive steps are taken to prevent the lines from being energized.

- Any part of the equipment does not have the ability to move laterally or horizontally within the minimum clearance specified in Table 4-1, from energized power lines.

- The equipment has been positioned and blocked to allow no part, including cables, to come within the minimum clearance specified in Table 5-1.

- Drilling operations will not be initiated within 25 feet of the verified position of underground power lines.

Table 5-1 Minimum Required Clearances for Energized Overhead Power Lines

Nominal System Voltage of Power Line Kilovolt (KV)	Minimum Required Clearance (feet)
0-50	10
51-100	12
101-200	15
201-300	20
301-500	25
501-750	35
751-1000	45

Source: OSHA 1910.180(j)(1)

5.8 NOISE

Noise exposure shall be controlled to levels below those stipulated in Table 5-2 or adequate hearing protection will be worn by all exposed personnel. Hearing protection will be worn any time noise levels exceed 85 dBA (decibels). The site safety officer shall be responsible for noise monitoring and issuance of plugs and/or muffs as deemed necessary.

When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effects of each. If the sum of the following fractions $C_1/T_1 + C_2/T_2 + C_n/T_n$ exceeds unity, then, the mixed exposure should be considered to exceed the limit value. C_n indicates the total time of exposure at a specified noise level, and T_n indicates the total time of exposure permitted at that level.

Exposure to impulsive or impact noise should not exceed 140 dBA peak sound pressure level.

Table 5-2 OSHA Permissible Noise Exposures (1910.95)

Duration per day, hours	Sound Level dBA Slow Response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

6.0 DRILLING SAFETY

A total of three soil borings drilled by mechanical methods are included in the scope of work. One of these soil borings will be located downgradient of the storage facility which is located on the University of Utah property, one will be located in the vicinity of Building 39, and one will be located in an area on the property to be excessed where no contaminants are expected to occur, in order to provide background information. The soil borings will be drilled to a depth of 30 feet. Should ground water be reached at either of the two nonbackground borings, monitoring wells will be installed.

The primary drilling method will be the hollow-stem auger method. Drilling by this method is accomplished by utilizing a hollow central shaft which is attached to a spiral scroll. A bit is attached at the bottom of the first auger flight. Cuttings created by the bit are removed by the scroll as the auger stem is turned. This method will be used unless conditions prevent completing the borehole. At that point, the auger will be withdrawn and the boring will be completed using a mud-rotary technique.

Mud-rotary drilling involves circulation of a drilling fluid, consisting of a mixture of powdered bentonite and water, down through the drill stem to cool the bit and back up the annular space of the borehole to bring cuttings to a portable mud pit at the surface. Cuttings settle out of the mud slurry to the bottom of the pit, and the mud is recirculated.

Installation of a monitoring well will be accomplished as follows. In the auger method, the casing is set in the annular space within the auger or drill pipe to ensure that the borehole remains open. When using the mud-rotary method, the casing will be installed in the open borehole filled with a column of mud. The filter pack will be placed in the annular space around the well screen extending from the base of the well to a level 2- to 5-ft above the top of the screen. In the auger method, the drill pipe is slowly pulled up as the filter pack is poured to allow the sand to fill the entire borehole. A bentonite seal, 2- to 5-ft thick will be placed above the filter pack. The seal will be composed of bentonite pellets or granules, or a bentonite slurry may be installed using a tremie pipe. The remaining annular space will be filled with neat cement-bentonite grout. The grout will be mechanically mixed and free of bumps.

There are general safety hazards common to both forms of drilling, as well as the installation of monitoring wells. In addition, there are hazards specific to using mud-rotary drilling, and to placing the seal in the wells. This section will address the safety precautions and regulations to be followed while drilling.

6.1 USATHAMA SAFETY PRECAUTIONS

The activities of core or well drilling for the purpose of soil and water sampling involve several safety hazards, i.e., flying debris, hydraulic failures, unguarded machinery, equipment rollover, fire, etc. Accordingly, the following minimum safety precautions will be implemented for contractors conducting drilling or coring operations on behalf of USATHAMA:

a. The drilling contractor shall have documented safety and emergency action procedures for the equipment to be operated. The drilling contractor's employees will acknowledge in writing that they have read and understand these procedures.

b. The drilling contractor shall ensure that the equipment is well maintained, meets safety requirements, is inspected daily during use, and has all required safety equipment; i.e., 20 lb A:B:C fire extinguisher, emergency stops, etc. Boring tools shall be in good condition and adequate for the work to be performed.

c. The drill rig shall be operated by a qualified operator who can identify pending failures and supervise the driller's helper(s). Transportation of the drill rig to the work site shall be performed by a person with proper commercial license.

d. To the extent possible, the terrain should be level and the condition of the ground such that unexpected movement of the drill rig is unlikely. If the slope of the terrain is hazardous, the USATHAMA project officer and the USATHAMA Safety and Environmental Services Branch will be contacted for the selection of a safe drill site.

6.2 INSPECTION

Each piece of potentially hazardous equipment (i.e., power tools, drilling apparatus, etc.) will be inspected for proper and safe operation prior to its use.

- All mechanical and rigging equipment will be inspected by the drillers prior to beginning this work effort, and at least daily thereafter to ensure proper operating capability. Defective equipment must be repaired or replaced prior to continued use/operation.

- Prior to commencing the drill cycle, the face and lifters shall be examined for misfires and, if found, they shall be removed before drilling. Lifters shall not be drilled through loose rock or water. The heading, including the face, shall be inspected for loose rock and scaled prior to mucking and drilling. Employees engaged in these activities will be protected from dislodgments by location, ground support, or other equivalent means.

6.3 GENERAL DRILLING SAFETY

- All drilling operation members must be continually aware of other's positions in regard to rotating equipment, cat head, U-joints, etc. and be extremely careful when assembling, lifting and carrying flights or pipe to avoid pinch point injuries and collisions.

- When a drill is being moved to another area, drill steel, tools, mast, and other equipment shall be secured in a safe position.

- Employees shall not be permitted on the drill mast when the drill bit is in operation.

6.4 MATERIAL HANDLING

Typical well drilling and well development activities involve rigging, pipe, casing, and pump handling, placement, and moving equipment. Wherever possible, the rig shall be used to move and place materials and equipment. When manual handling/placement is required, the use of the "buddy system" and proper lifting techniques shall be used to prevent sprain or strain injuries.

Handling, mixing and placement of silica sand, bentonite, grout, and concrete are also typical activities. Respirators with HEPA filters are required whenever silica sand is handled. Approved dust respirators are also required when dust is visible while handling the other materials. Impermeable gloves shall be worn when handling grout, concrete or other chemical substances to prevent irritation, absorption, or burns due to the caustic or toxic nature of these materials.

6.5 CONTAMINATION REDUCTION

Drilling and sampling should be performed in such a manner so as to prevent, or reduce any splashing, dusting, or other contamination of the employee or his/her personal protective equipment.

6.6 SPECIAL DRILLING PRECAUTIONS

In the event that mud-rotary drilling or monitoring-well installation should take place, the discharging of the mud or slurry into the boring using either a discharge line or tremie pipe poses some hazards. The mud or slurry can lodge in the line or pipe and prevent the pressure from equalizing between the pipe and the surrounding borehole, resulting in the discharge line or tremie pipe still being under high pressure when disconnected. Disconnecting either the line or pipe under high pressure may cause the spewing of the mud or slurry, and may cause the line or pipe to move in a violent and uncontrolled manner. In the case of mud-rotary drilling, drilling personnel will constantly monitor the flow of mud from the surface pit into the hole, and the flow of mud out of the hole. Should a reduction in either be noted, the drilling will be stopped and the situation assessed. One possible outcome may be to increase the amount of water flowing into the pipe in an effort to dislodge the mud. If this method is chosen, all personnel will be moved away from the hole to avoid injury. In the case of setting the well, personnel will constantly monitor the flow of the slurry into the tremie pipe. Should a reduction in flow occur, the procedure will be stopped and the situation assessed. Personnel will be moved away from the hole.

7.0 BIOLOGICAL HAZARDS

The following categories of biological hazards could be encountered at this site:

- Snakes
- Insects
- Mammals

7.1 SNAKES

Personnel should exercise caution for the possible presence of rattlesnakes at the site. Rattlesnakes favor cool, shady areas near water. The vicinity of well sites and drill rigs may be favorable for rattlesnakes.

7.2 INSECTS

The most common insects of concern in this area are ticks, spiders, fleas, and bees. Ticks can be picked up on clothing in wooded and grassy areas. Preventive measures include careful inspection of clothing and body parts on a daily basis. In the event that someone is bitten by a tick, it should be removed carefully and the incident reported to the SSO. In the event that the tick is not completely removed, medical attention should be sought. Black widow spiders may be present under rocks, fallen tree branches, or other ground debris. Care should be taken when moving or rummaging around such areas and the use of gloves is recommended. Fleas can be picked up from contact with animals or animal burrows. The best prevention is to avoid such contact. Bees or wasps, such as yellow jackets, often nest in the ground and may be disturbed by traversing or digging in the area where they are nesting. Anyone allergic to bee stings should notify the SSO at the start of the project and be given prompt medical attention if stung during the course of the work. Other biting insects such as horse flies, deer flies, and mosquitos may also pose a nuisance to site workers. Any excessive swelling or allergic reactions to insect bites should be reported to the SSO and given prompt medical attention.

7.3 MAMMALS

Rodents, badgers, coyotes, and foxes are some of the wild mammals indigenous to this area. They are typically shy of humans and will try to escape if encountered. Situations where these animals become aggressive include the defense of their young or their homes, or when injured or sick. Avoid contact with any wild mammals on the site. If any animals need to be removed from the site contact the Fort Douglas Representative for instructions. If bitten by an animal exhibiting uncharacteristic behavior, there is a possibility that the animal is rabid. If this happens, the animal should be captured, if possible, and diagnosed for the presence of rabies. The victim should be given immediate medical attention.

8.0 AIR MONITORING

Air monitoring equipment will be used during field activities to indicate levels of gaseous and particulate contaminants. The use of this equipment is intended to provide warning and to allow appropriate action to be taken to prevent worker exposure. Air monitoring will be performed at the start of any drilling operation, and readings will be taken at intervals of no more than 15 minutes throughout the entire drilling procedure. Based on the presence of a contaminant of concern, the determination to upgrade/downgrade levels of protection will be made by the SSO. Calibration procedures for air monitoring instruments are included in Appendix E.

8.1 ORGANIC VAPORS

The vapors associated with the organic contaminants shall be monitored with an organic vapor analyzer (OVA) or a PID and preliminary compound identification shall be performed using compound-specific colorimetric tubes. These devices shall be calibrated on a daily basis by the Site Safety Officer using the technique and calibration gases specified by the manufacturer. NIOSH techniques for sampling and analysis may be employed if elevated levels of total organics are detected in the breathing zone of workers.

Action Levels
Organic Vapors

0 - 4 ppm above background in the breathing zone.......Notify SSO
≥5 ppm above background in the breathing zone..........Interrupt tasks/move to support zone

If a reading of >1 ppm above background in the breathing zone is reached on the OVA or PID, the SSO will test the air for the presence of benzene using benzene-specific colorimetric tubes, and for 1,1,2,2-tetrachloroethane using colorimetric tubes specific for that chemical. If either or both tests are positive, respiratory protection will be increased to full facepiece air purifying respirators with organic vapor or combination cartridges. If neither test is positive, work may continue in level D respiratory protection until a level of 25 ppm above background in the breathing zone is reached. At this point, full facepiece air purifying respirators with organic vapor or combination cartridges will be donned.

8.2 FLAMMABILITY

A combustible gas meter shall be used to monitor the potential for explosive concentrations of organic vapors during the initial phase of drilling. Monitoring shall continue if 2 percent of the lower explosive limit (LEL) is exceeded at any time. Work shall cease if the LEL reaches or exceeds 20 percent. The combustible gas meter shall be calibrated to the manufacturer's specifications each day prior to use.

Action Levels

Combustible Gases

2.0-10.0% LEL	Continue monitoring
10.0-19.0% LEL	Notify SSO
20.0% LEL or greater	Potential Explosion Hazard - Interrupt Task/Evacuate

Oxygen Concentration

20.8 % O_2	Oxygen Normal
<20.8% O_2 but >19.5 % O_2	Oxygen Deficient - Notify SSO
< 19.5% O_2	Oxygen Deficient - Interrupt Task/Evacuate

9.0 SITE CONTROL

9.1 ZONING

The establishment of work zones will ensure that: personnel are properly protected against the potential hazards in the area where they are working; work activities and potential contamination are limited to the specific areas; and personnel can be easily located and evacuated in an emergency.

Work zones designated for drilling and sampling will be established and communicated to all employees by the Site Safety Officer (SSO). The zones include:

Exclusion Zone ("Hot Zone") - area where contamination does or could occur. The primary activities performed in the exclusion zone include:

- sampling; and
- drill rig operation.

All personnel entering the exclusion zone must wear the prescribed level of protection. The hotline (outer boundary of the exclusion zone) for drilling activities can be minimally defined as the area 25 feet in radius originating at the proposed drilling/sampling point. An entire floor of a building (e.g., the basement when sampling pipe insulation) may be considered the Exclusion Zone. Personnel working in the exclusion zone may include the Project Manager, drill rig operators, and sample collection personnel. Within the zone, different levels of protection may be justified based on the degree of hazard presented. The level of personal protection required in each sub-area is specified in Section 13.

Contamination Reduction Zone - transition area between the contaminated area and the clean area. This zone is designed to reduce the probability that the uncontaminated support zone (clean area) will become contaminated or affected by other site hazards. It is the area where decontamination of personnel and equipment takes place and serves to limit the physical transfer of hazardous substances into clean areas. Any potentially contaminated personnel, clothing, equipment, and samples must remain in the contamination-reduction zone until thoroughly decontaminated. Decontamination of personnel and equipment will be performed as described in Section 10.

Support Zone - outermost part of the site which is considered noncontaminated or "clean". The support zone is the location of administrative and other support functions (e.g., equipment storage and calibration). Any function that need not or cannot be performed in a hazardous or potentially hazardous area is to be performed here.

9.2 ACCESS

Access to either the exclusion or contamination reduction zones will be strictly controlled. Only personnel who are essential to the completion of the task will be allowed access to these areas, provided they have the proper training and qualifications and are wearing the prescribed level of protection. Direct communication will be maintained with workers in the exclusion zone at all times. Communication between work sites will be by radio. A radio telephone will be used for off-site communications. Section 14.4 contains a list of emergency telephone numbers.

The names of employees working on-site will be recorded daily. Additional record keeping requirements are identified in Section 15.

9.3 DELINEATION

Once designated, the exclusion zone will be conspicuously identified through the use of traffic cones, flags, ropes, surveyors tape, or other suitable means.

9.4 THE BUDDY SYSTEM

Most activities in contaminated or otherwise hazardous areas are to be conducted with a buddy who is able to:

- provide his/her partner with assistance,
- observe his/her partner for signs of chemical or heat/cold exposure,
- periodically check the integrity of his/her partner's protective clothing, and
- notify the Site Safety Officer or others if emergency help is needed.

The majority of tasks to be performed at Fort Douglas are not considered hazardous. Situations when the buddy system is required includes sampling of transformers and during drilling operations. Other tasks, such as lead paint sampling, can be done alone as long as radio contact is maintained with the support area.

9.5 PERSONAL HYGIENE

Separate drinking water and handwashing facilities will be available at each site. Each container shall be clearly labeled as to its contents, and the containers shall not be the same color. Disposable cups will be provided, as well as covered refuse disposal containers. Employees must keep the site clean at all times in case animals, such as rodents and insects, are drawn to the refuse. If toilets are not immediately available at the site, locations of these facilities will be communicated to every employee and transportation will be available.

Hygiene facilities will be located outside of the exclusion zone, in proximity to the entry/exit, when possible (unless specific decontamination requirements dictate otherwise - see Section 10). Eating, drinking, smoking, chewing (gum, tobacco, etc.) or applying cosmetics are not permitted inside the exclusion or contamination reduction zones. Other activities which may facilitate the hand-to-mouth transfer of contaminants should also be avoided.

Employees should take reasonable precautions to ensure that they do not come in direct contact with solid or liquid from the sampling areas; this includes sampling and monitoring equipment. Employees should drink plenty of water during hot periods to ensure adequate hydration, in an effort to prevent heat stress.

Following decontamination procedures, or any time when leaving the exclusion zone, personnel are required to wash their hands and face thoroughly. Hygiene facilities will be maintained in a clean and sanitary manner at all times.

9.6 SAFE WORK PRACTICES

The following general safe work practices will be observed during field activities:

- Hard hat and safety eye protection will be worn when inside the drilling exclusion zone.

- Appropriate foot, hearing, and hand protection will be worn by those directly involved in the work efforts when warranted.

- No facial hair that interferes with face-to-mask seal of respirators will be allowed.

- If contact lenses are worn by those directly involved with the work efforts, chemical splash goggles shall also be worn.

- Contact lenses will not be worn with full-face respirators.

- Personnel not involved in the operation of the drill rig or monitoring activities will remain a safe distance from the rig.

- Personnel must maintain a high level of awareness of the limitations in mobility, dexterity, and visual impairment inherent in the use of personal protective equipment.

- Housekeeping must be practiced continually - tools, equipment hoses, cords, etc. must be kept off the ground wherever possible to avoid tripping hazards and to prevent the spread of contamination.

- Illumination levels during work at the site will be a minimum of 5-ft candles in all locations.

- Portable generators shall have an effective ground rod installed and bonded.

- Ground fault circuit interrupters should be used wherever possible.

- A morning safety meeting will be conducted for all personnel as a required activity. The safety procedures, and the day's planned activities will be discussed. The contractor/subcontractor will emphasize compliance with state, local, and installation motor vehicle laws and regulations as a part of each daily safety briefing. Additionally, any special considerations pertaining to motor vehicle safety, i.e., current or anticipated hazardous road conditions, etc., will be addressed at the daily safety briefings.

- No drilling activities will be conducted during thundershowers or during periods of potential lightning.

- All personnel must completely decontaminate prior to using Fort Douglas facility restrooms or "porta-johns."

- Outdoor work activities will be limited to periods of daylight. Night work is not permitted.

10.0 DECONTAMINATION

During drilling and sampling activities at the site, field workers may become contaminated in several ways, including contact with: airborne vapors, gases, dusts, mists, or fibers; splashes, spills, when walking through contaminated areas, and when handling contaminated equipment.

10.1 PERSONNEL DECONTAMINATION

Detailed decontamination procedures for each level of PPE are described in Appendix F. As PPE levels change, decontamination procedures will be adjusted accordingly.

10.2 EQUIPMENT DECONTAMINATION

10.2.1 SAMPLING AND MONITORING EQUIPMENT

All possible measures should be taken by personnel to prevent or limit the contamination of any sampling or monitoring equipment. Sampling devices will require decontamination. Any delicate instrument that cannot be easily decontaminated should be protected by placing it in a plastic bag and using tape to secure it around the instrument. Openings in the bag can be made for sample intake, electrical, and probe connections.

10.2.2 HEAVY EQUIPMENT AND TOOLS

All possible measures shall be taken to prevent or limit the contamination of heavy equipment. Those parts of drilling equipment that become contaminated, such as auger flights, will be decontaminated before reuse to minimize personnel contamination and cross contamination of samples between bore holes.

Before taking the drill rig and associated tools or other pieces of heavy equipment onto another site, they shall be completely steam cleaned. If the rig and/or tools are contaminated with chemicals, the water will be captured in a containment area and disposed of properly. The location for such equipment decontamination will be determined on site.

10.2.3 RESPIRATORY EQUIPMENT

All respiratory equipment will be placed into containers (separate from clothing) in the decontamination corridor and washed with a disinfectant, thoroughly rinsed, and dried prior to re-use.

10.2.4 FATE OF INVESTIGATION DERIVED MATERIALS

All waste products generated as part of the investigation will be contained on-site until results on the nature and extent of contamination can be determined. These waste products include but are not limited to: personal protective clothing, respirator cartridges, boot covers, drill shavings, decontamination water, well development water, and any plastic coverings utilized on-site. The waste shall be contained in the following manner:

- Used, uncontaminated protective clothing: Bag and dispose of as sanitary waste as directed by the Fort Douglas Commanders Representative.

- Used chemically contaminated protective clothing: Double bag and dispose of as directed by the Project Manager.

- Drill cuttings: Contain in plastic lined steel drums until laboratory analysis data becomes available.

- Well development water and decontamination water: Capture and contain in a 55-gallon drum until laboratory analysis data becomes available.

11.0 MEDICAL SURVEILLANCE

11.1 BASELINE MEDICAL EXAMINATIONS

All personnel involved in work activities at the site shall have a pre-task medical examination within the past year, including:

- physical examination;
- pulmonary function testing;
- blood chemistry;
- urine chemistry; and
- review of employee occupational and medical history.

The purpose of the physical examination is to: (a) obtain background blood and urine chemistries; (b) note conditions that could increase susceptibility to heat stress; and (c) determine the ability of personnel to wear respirators.

Employees who are clearly unable to perform the required tasks based on medical history and physical examination (i.e., those with lung, heart, liver, or kidney functional impairments), as determined by the individuals's physician, will be prohibited from working in contaminated areas.

11.2 FREQUENCY OF MEDICAL EXAMS

Additional medical examinations will be performed whenever there is an actual or suspected excessive exposure to contaminants; following injuries or temperature stresses; or if symptoms of exposure are experienced or as required by a physician.

11.3 PHYSICIAN APPROVAL

Medical examinations will be performed by an occupational physician designated or approved by Stollar.

11.4 USE OF CONTACT LENSES

The use of contact lenses is prohibited during any activity which requires the use of respirators.

12.0 TRAINING AND EDUCATION

12.1 HAZARDOUS MATERIALS WORKER (DRILLERS, GEOLOGISTS/HYDROLOGISTS, INSPECTORS, TECHNICIANS)

Each employee directly involved with sampling, well drilling, and other associated project tasks within the exclusion zone is required to complete the following training prior to starting work at the site:

- A 40-hour course as defined in 29 CFR 1910.120. An annual refresher course is required for workers not in compliance with the standard.

- Three days supervised experience at a hazardous waste site.

- Pre-job Safety Meeting, to include the following:

    1. Site control and management
    2. Safe sampling techniques
    3. Job Safety Analysis, including PPE
    4. Proper decontamination for personnel and equipment
    5. Emergency preparedness plan and procedures
    6. Employee rights and responsibilities
    7. Exposure potentials and mitigation steps
    8. General safe work practices
    9. Hazard Communication Program

12.2 HAZARDOUS MATERIALS SUPERVISOR

Supervisors of hazardous material workers are required to complete all training in Section 12.1, plus an 8-hour Hazardous Material Supervisors course as defined in 29 CFR 1910.120.

12.3 SITE SAFETY OFFICER

The Site Safety Officer is required to complete all training in Sections 12.1 and 12.2, plus:

- such training as may be necessary for the proper operation, calibration and interpretation of sampling/monitoring devices they will be using;

- fundamental instruction in health and safety hazard recognition; and

- adult first aid and cardiopulmonary resuscitation (CPR).

12.4 ASBESTOS SAMPLERS

In addition to the training required by Hazardous Materials Workers (Section 12.1 above), workers who will be sampling for asbestos will also be trained Asbestos Building Inspectors as defined under the Asbestos Hazard Emergency Response Act (AHERA). While AHERA regulations apply to abatement work performed in school buildings only, the regulations provide the best knowledge in building inspection and sampling techniques.

12.5 VISITORS AND SUPPORT PERSONNEL

Untrained visitors and support personnel will not be allowed access to the exclusion zone. Additionally, each trained visitor and support person having a "need" to access the exclusion zone shall receive a briefing on the HASP prior to entry. Each visitor and support person shall be escorted by the Site Safety Officer or the Project Manager at all times.

13.0 PERSONAL PROTECTIVE EQUIPMENT

13.1 CHEMICAL PROTECTIVE CLOTHING

Minimum personal protective equipment requirements will be determined for each on-site activity by the SSO. Additional or optional items that may be used for an on-site activity will be determined by the SSO. The SSO will ensure that the material used in the construction of chemical resistant clothing is compatible with the chemical hazards anticipated and will provide the wearer adequate protection. The Personal Protective Equipment Program for the Fort Douglas EI is included in Appendix G.

Although the chemicals expected on-site have the potential to adversely impact human health, based on the activities approved under this HASP, and the relative concentrations of the known contaminants, the overall chemical, asbestos, lead and PCB hazards can be characterized as low. Level C or D protective equipment will be adequate to safeguard workers from conceivable hazards.

Descriptions of the equipment that constitutes Levels C and D are given below.

Level C: Level C protection should be worn when using air-purifying respirators. Level C consists of:

- Full facepiece or half facepiece air purifying respirator with HEPA, organic vapor, or combination cartridges;
- Chemical resistant clothing (hooded, one- or two-piece chemical splash suit or disposable chemical-resistant one-piece suit);
- Inner chemical resistant gloves (surgical/latex gloves);
- Outer chemical resistant gloves;
- Leather safety boots with disposable covers or chemical resistant safety boots;
- Hard hat (optional);

- Cotton coveralls (optional);
- Face shield (optional);
- Two-way radio (optional).

Level D: Level D protection should be worn only as a work uniform and not on any job with respiratory or skin hazards. Level D can consist of:

- Coveralls (cotton or Tyvek);
- Safety boots or shoes;
- Safety glasses or goggles;
- Hard hat (optional);
- Gloves (optional);
- Face shield (optional);

13.2 LEVELS OF PROTECTION REQUIRED

Task	Personal Protective Equipment
Asbestos Sampling	Tyvek coveralls, safety goggles, latex gloves, steel-toed boots, half-facepiece air purifying respirator with HEPA filter cartridges.
PCB Sampling	Air-purifying full-face respirators with combination HEPA/organic vapor cartridges, Tyvek coveralls, neoprene or Viton outer gloves, latex inner gloves, steel-toed boots, hard hat, safety goggles.
Lead Paint Sampling	Cotton coveralls, steel-toed boots, safety goggles, latex gloves.

Drilling Operations and Ground-Water Sampling	When the PID reads 25 ppm or less and benzene and/or 1,1,2,2-tetrachloroethane have not been detected using colorimetric tubes: cotton coveralls, safety goggles, latex inner gloves, nitrile outer gloves, goggles, latex inner gloves, nitrile outer gloves, steel-toed boots, hard hat. When benzene or 1,1,2,2-tetrachloroethane have been detected using colorimetric tubes, or when the PID reads 25 ppm and benzene and/or 1,1,2,2-tetrachloroethane have not been detected: Tyvek coveralls (Saranex will be used for ground-water sampling) steel-toed boots, hard hat, nitrile outer gloves, latex inner gloves, full-facepiece air-purifying respirator with organic vapor cartridges.

The SSO has the authority to modify the personal protective equipment requirements, as the situation dictates.

14.0 EMERGENCY PREPAREDNESS AND PROCEDURES

14.1 SITE EMERGENCY COORDINATOR

Site Emergency Coordinator:	Brian Myller or alternate Project Manager
Alternate Site Emergency Coordinators:	Joan Henehan or alternate Site Safety Officer

The emergency coordinator or an alternate shall implement this contingency plan in the event of an explosion, fire, release of hazardous waste, or whenever conditions at the site warrant such action. The coordinator will be responsible for assuring the evacuation, emergency treatment, emergency transport of site personnel as necessary, notification of emergency response units, and the appropriate management staff. This contingency plan will detail evacuation procedures to be used, if needed, during the investigation.

14.2 COMMUNICATIONS

- Communications between work sites will be by radio. A radio telephone will be used for off-site communications. See Section 14.4 for emergency telephone numbers. All numbers dialed on the radio telephone must be preceded by the network access code which will be securely taped to the instrument.

- A series of three (3) 1-second horn blasts from an air or automobile horn is the emergency signal for all personnel to leave the exclusion zone.

14.3 BUDDY SYSTEM

As described in Section 9.4 the buddy system shall be used by all persons at all times in the exclusion zone. The maximum direct line-of-sight distance between persons is 100 yards.

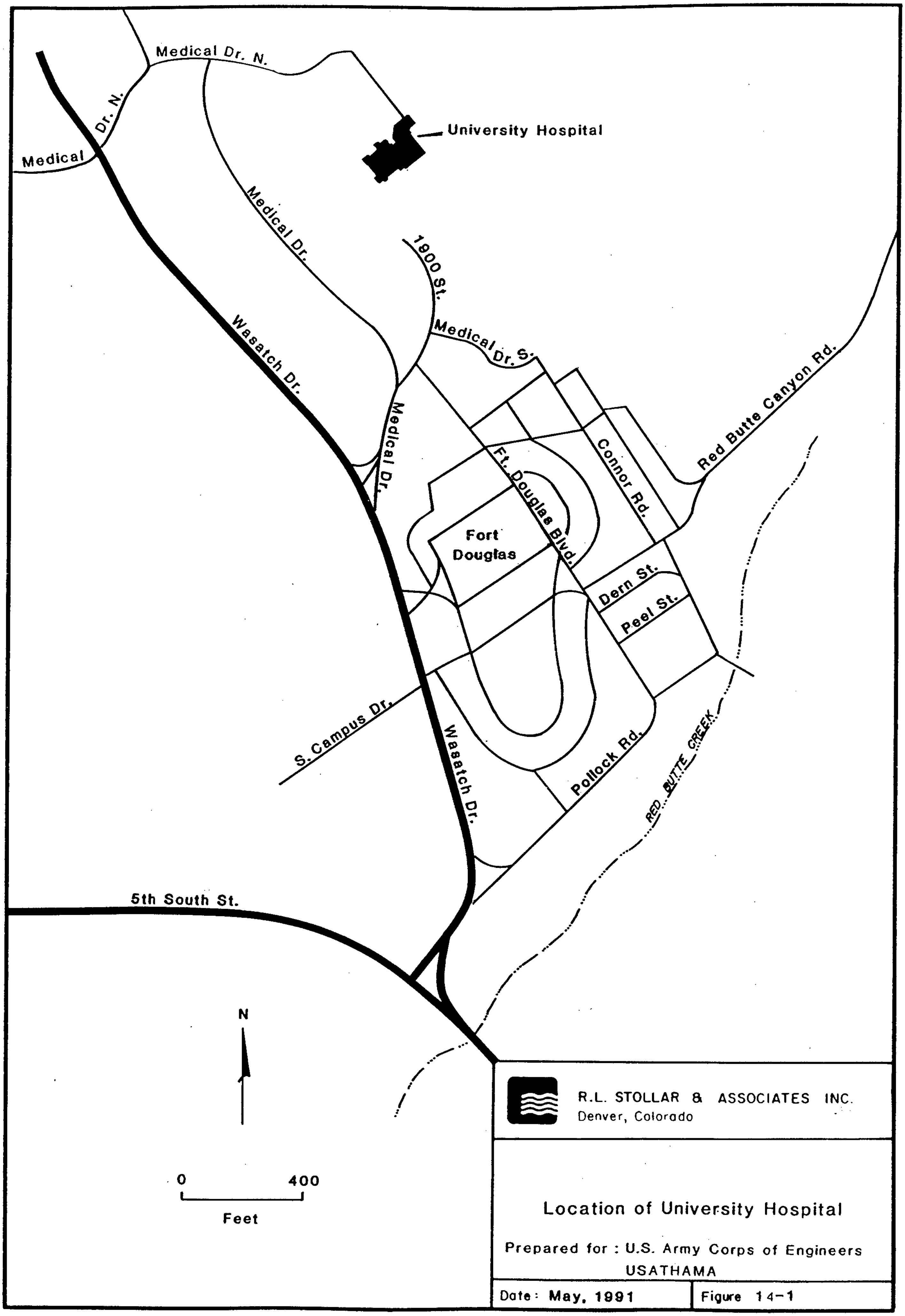
14.4 EMERGENCY NUMBERS AND LOCATIONS

Ambulance:	911
Hospital:	911

Police:	911
Fire/Rescue:	911
Sheriff (Hall County):	911
Poison Control Center:	University Hospital Poison Control 50 North Medical Drive (801) 581-2151
FD Emergency Contact:	Mr. Gary Silvers Director of Engineering and Housing (801) 524-4207
Off-site Medical Facility	University Hospital Emergency 50 North Medical Drive (801) 581-2291
Directions to Off-site Medical Facility	Figure 14-1 shows the location of University Hospital. From any point on Ft. Douglas Medical Facility proceed to Wasatch Drive (the southwestern boundary of the Base). Go north on Wasatch Drive until it splits into Medical Drive. Go right onto Medical Drive. Proceed on Medical Drive to Medical Drive North. Turn right onto Medical Drive North to University Hospital.
Stollar Project Manager	Mr. Brian Myller (303) 831-8868 (801) 524-4207
Site Health and Safety Officer	Joan Henehan or alternate (303) 420-4303 (801) 524-4207
Fort Douglas Commander's Representative	Mr. Edward Richardson Director of Engineering and Housing (801) 524-4207
USATHAMA Contracting Officer's Representative	Mr. Mark Mahoney (301) 671-1629

14.5 FIRST AID

The SSO must be trained in First Aid/CPR and must identify at least one additional individual with these training requirements. At a minimum, one of these two individuals must be present on the work



R.L. STOLLAR & ASSOCIATES INC.
Denver, Colorado

Location of University Hospital

Prepared for : U.S. Army Corps of Engineers
USATHAMA

Date: May, 1991

Figure 14-1

site at all times while work is being performed. Additionally, these two individuals will become familiar with the location of, and the directions to the University Hospital which are provided above.

An adequately supplied first aid kit will be on-site at all times. Additionally, a minimum of three 32-ounce bottles of eye wash solution will be kept at each work site at all times.

14.6 FIRE PREVENTION/PROTECTION

At least one 10-pound fire extinguisher will be at each drilling site at all times. Smoking will be restricted to the inside of vehicles, or within areas cleared of vegetation. Smoking is not permitted inside the exclusion zone or contamination reduction zone.

Upon notification of a fire or explosion, the emergency signal of three (3) 1-second blasts will be sounded and all site personnel will exit the site in an upwind direction. It is understood that efforts to extinguish the fire may only be undertaken by personnel when the risk is minimal to themselves. However, if the situation is in doubt, leave the immediate area and assemble at the decontamination area. The emergency coordinator will immediately evacuate the site (air horn or automobile horn will sound three times at 5-second intervals). The emergency coordinator will summon the Salt Lake City Fire Department by dialing 911, and other emergency response groups if LEL values remain above 20 percent in the work zone for a sustained period of time or if an actual fire or explosion has taken place. See Section 14.4 for the list of emergency phone numbers.

14.7 EVACUATION ROUTES

In the event of an emergency, such as fire, explosion, release of toxic materials, etc., the emergency signal of three (3) 1-second horn blasts will be sounded. This signal will initiate site evacuation plans and all personnel will exit the site in an upwind direction. Personnel inside a building upon occurrence of an emergency will exit the building by the safest, most direct means and assemble upwind of the building. Following an emergency and evacuation the SSO or Superintendent will be responsible for taking and reporting a headcount. For efficient and safe site evacuation, and assessment of the emergency situation, the Project Manager or SSO will have the authority to initiate proper action if outside services are required. The SSO or Project Manger must see that access for emergency equipment is provided and all sources of combustion have been shut down. Under no circumstances will incoming personnel or visitors be allowed to proceed into the area once the signal has been given. Evacuation routes and assembly areas shall be a topic of each safety meeting held at the work site.

14.8 PERSONAL INJURY - INSIDE EXCLUSION ZONE

Important: Should an injury occur inside the exclusion zone, proper protection for responding emergency personnel must be taken into consideration, as well as decontamination of the injured person. However, the first priority in any injury situation is the health and welfare of the injured. Moving an injured person should never be done unless it can be done without further harm.

Upon notification of an injury inside the exclusion zone, the emergency signal of three (3) 1-second horn blasts will be sounded. All site personnel outside of the exclusion zone will assemble at the entry/exit. The injured person will be taken to the decontamination area, if possible, where the Site Safety Officer or the Project Manager will evaluate the extent of the injury and the extent of decontamination possible prior to movement of the injured person outside the exclusion zone for treatment or transport. The ambulance will be summoned, as necessary. No person should re-enter the exclusion zone until the cause of the injury is determined and measures are taken to prevent a recurrence.

14.9 PERSONAL INJURY - OUTSIDE EXCLUSION ZONE

The same general procedure described above should be followed. However, if the injury does not affect safe performance or the safety of site personnel, activities inside the exclusion zone may continue. If the injury increases the risk to others, the emergency signal to evacuate the exclusion zone shall be sounded and all personnel shall move to the decontamination area for further instruction. The injured person should be evaluated for necessary treatment and either transported to the designated medical facility or an ambulance summoned.

14.10 PHYSICAL EXPOSURE

If an injury to a worker is chemical in nature, the following first aid procedure(s) are to be instituted as soon as possible:

- Eye Exposure - If contaminated solid or liquid gets into the eyes, wash the eyes immediately with an emergency eye wash using large amounts of eye wash and lifting the lower and upper lids occasionally (emergency eye wash solution will be provided at each site). Obtain medical attention immediately by calling 911.

- Inhalation Exposure - If a person shows signs of overexposure to airborne contaminants, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. If breathing and heart have both stopped, perform CPR. Obtain medical attention immediately by calling 911.

- Ingestion - If contaminated solid or liquid has been swallowed, immediately obtain medical attention and call the Poison Control Center (801) 581 -2151.

- Puncture wound or laceration - Decontaminate, stop the bleeding, and if necessary transport to an emergency medical facility.

14.11 ACCIDENT REPORTING

Accidents resulting in a fatality, lost-time injury or illness, hospitalization of five or more personnel, or property damage to government or contractor property equal to or exceeding $2,000 must be reported by telephone to the Stollar Project Manager, (303) 831-8868 and to USATHAMA, CETHA-TS, (301) 671-4811, as soon as possible, but no later than 2 hours after occurrence. The accident will be reported in writing within 5 days of occurrence on ENG Form 3394 and the Stollar Accident Form (Appendix A). All other accidents/incidents must be reported by telephone to Stollar and the Fort Douglas representative, USATHAMA, CETHA-TS, within 8 hours of occurrence, or sooner if conditions permit.

All injuries will be reported regardless of whether the incident appears to be serious or not. Likewise any exposure will be reported even though there may be no adverse health effects or symptoms apparent initially. This is primarily because an exposure to a toxic agent may often have delayed or latent effects which can only be detected by specific diagnostic tests. Documenting an exposure may aid in identifying the cause of symptoms. Similarly, an injury, such as an eye injury caused by contaminated dust, may result in delayed damage to the eye.

14.12 PERSONAL PROTECTIVE EQUIPMENT FAILURE

If any site worker experiences a failure or alteration of PPE that affects the protection factor, that person and his/her buddy shall immediately leave the exclusion zone. Re-entry will not be permitted until the equipment has been repaired or replaced, or the conditions leading to the problem are evaluated and corrected.

14.13 FAILURE OF OTHER EQUIPMENT

If equipment on site fails to operate properly, the SSO and/or Project Manger will be notified to determine the effect of the failure on continuing operations. If the failure affects the safety of personnel (e.g., monitoring equipment) or prevents completion of the work plan tasks, all personnel will leave the exclusion zone until the necessary repairs are made.

14.14 ENVIRONMENTAL PROTECTION AND RESPONSE

Frequent inspections will be conducted under and around equipment to identify leaks. When small leaks are noted, the ground will be protected with plastic (or equivalent) to prevent soil contamination. When large leaks are identified, the equipment will be shut down until necessary repairs are completed.

Where contamination of earth or liquid is suspected or known, such contaminated material shall be placed on impermeable plastic or placed in an appropriate container until such time as the extent of contamination is determined, and/or disposal of this material is specified.

In the event of an environmental release, the SSO will take action to control or stop the spread of contamination if possible. If a significant release has occurred, the SSO will contact the Salt Lake City Fire/Hazmat Department and other response groups for the possible or immediate need for neighborhood evacuation. If a significant release has occurred, the Fort Douglas Commander's representative, Mr. Gary Silvers, will be contacted at (801) 524-4207. Fort Douglas personnel will alert National or Regional Response teams as necessary. Following these calls, the reporting individual will notify the Project Manager, SSO, or Site Superintendent.

14.15 PCB SPILL RESPONSE PROCEDURES

A spill response kit will be available at the sampling location when transformers are opened. The kit will include a 55-gallon open-head drum, neoprene or Viton gloves, respirators with combination organic vapor/HEPA cartridges, Saranex coveralls, and absorbent material (sand, sawdust, etc). In the event of a PCB spill under a transformer, the following procedures will be followed:

- Use absorbent material to keep the spill from spreading.
- Work the absorbent material into the spill with a broom. Dispose of the broom with other PCB-contaminated materials.
- Shovel the absorbent material into an approved PCB container.
- Excavate all contaminated soil from the spill area and a buffer of 1 lateral foot of clean soil and place in the waste container.
- Rinse any tools used, such as shovels, with soapy water and dispose of the rinse water with the PCBs.

15.0 RECORDKEEPING

15.1 HEALTH AND SAFETY PLAN SIGN-OFF

All personnel entering the exclusion zone to perform work activities shall read the Health and Safety Plan, and sign the signature sheet indicating their understanding and commitment to follow its provisions.

Persons entering the exclusion zone for purposes of short-term visits will be briefed by the Site Safety Officer or the Project Manager prior to entry. The briefing person will document this on the signature sheet next to the visitor's signature.

15.2 DAILY HEALTH AND SAFETY LOG

A daily health and safety (air monitoring) log must be maintained by the site safety officer. This log shall include, at a minimum, the following information: description of the field work being conducted, any changes in the operation, names of all personnel working at the site, types of air monitoring equipment being used and how calibrated, air monitoring results, level of personal protective equipment being worn, accidents and injuries, and a description of any unusual occurrences or physical complaints. Copies of the logs must be provided to USATHAMA, CETHA-TS-S, weekly during field activities. It is acceptable to facsimile copies to CETHA-TS-S at (301) 671-3132.

15.3 MONITORING RESULTS

All field-determined monitoring results will be recorded on the site log and made part of the HASP. Monitoring results reported away from the field will be made part of the HASP when received. All drill site and sampling personnel shall be given the opportunity to witness monitoring, and to see the results of the monitoring.

15.4 POTENTIAL EXPOSURE LOGS

When levels of contaminants are measured above background on detection instruments, a potential exposure log shall be completed for all personnel entering the exclusion zone for the period during which the contaminant levels are being registered.

15.5 EMPLOYEE EXPOSURE NOTIFICATION

Exposure notification to employees shall be in accordance with OSHA requirements. Medical surveillance personnel will be notified of employee exposure at the time of scheduled examination, or when required.

16.0 REFERENCES

Dames and Moore, 1991. Base Closure Final Environmental Impact Statement for Fort Douglas, UT. Prepared for the Department of the Army Headquarters, FORCES Command Fort McPherson, GA.

Weston, R. F., Inc. (Weston), 1989. Enhanced Preliminary Assessment, Task Order 2, Fort Douglas, Salt Lake City, Utah. Prepared for U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland.

APPENDIX A

FORMS

HEALTH AND SAFETY PLAN ACCEPTANCE FORM

Instructions: This form is to be completed by each person to work on the subject project work site and returned to the Project Manager and Safety Coordinator.

Project Name: ______________________

Project Number: ______________________

Date: ______________________

I represent that I have read and understand the contents of the above plan and agree to perform my work in accordance with it.

____
Name (Print)

____
Signature

____
Date

____
Company/Division

ENVIRONMENTAL MONITORING

Description

Name(s):______________________ Project Name:__________________________

Date:________________________ Project Number:________________________

Location:____

Weather Conditions:____

Estimated Wind Direction:____

Estimated Wind Speed:____

Background Level:____

Location of Background Level:_____________________________________

On-Site Activities Conducted:_____________________________________

____

Combustible Gas Indicator:_______________________________________

Colorimetric Tubes (Type):_______________________________________

HNU/OVA:____

Other:____

____

____

ACCIDENT REPORT FORM

TO: ______________________________

FROM: ______________________________

Name of Injured or Ill Employee: ____

Date of Accident: ______________________ Time of Accident: ______________

Exact Location of Accident: ____

Project Name/Number: ____

Description of Accident: ____

____

____

____

Nature of Illness or Injury and Part of Body Involved: ______________________

____

Corrective Action Taken: ____

____

____

Corrective Action Remaining to be Taken (By Whom and By When): ______________

____

____

What can be done to prevent a recurrence of this type of accident? ______________

____

____

Signature of Supervisor/Manager: ____

Date: ______________________

NOTE: Do Not Use For Vehicle Accidents

EXPOSURE HISTORY FORM

Project Name:____________________

Project Number:____________________

Location:____________________

Dates From/To:____________________

ON-SITE PERSONNEL

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________
11. ____________________
12. ____________________
13. ____________________
14. ____________________
15. ____________________
16. ____________________
17. ____________________
18. ____________________
19. ____________________
20. ____________________

SUSPECTED CONTAMINANTS

VERIFIED CONTAMINANTS

AIRBORNE CONCENTRATION

INSTRUMENT CALIBRATION CHECK SHEET

Instrument: ______________________________

Serial Number: ______________________________

Date: ______________________________

Calibrated By: ______________________________

Pure Air: Y/N

Calibration Gas (PPM)

Battery Check: Good/Bad

NOTES:

APPENDIX B

CHEMICAL HAZARD INFORMATION

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR ASBESTOS

POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

This guideline summarizes pertinent information about asbestos for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

Data in the following section are presented for various forms of asbestos: (1) Asbestos (mixed forms);
(2) Chrysotile;
(3) Amosite;
(4) Crocidolite;
(5) Tremolite;
(6) Anthophyllite;
(7) Actinolite.
If unspecified, data apply to all forms.

- **Composition:** (1) Not Available;
(2) $3MgO-2SiO_2-2H2O$;
(3) $(FeMg)SiO_3$;
(4) $NaFe(SiO_3)_2-FeSiO_3-H_2O$;
(5) $Ca_2Mg_5Si_8O_{22}(OH)_2$;
(6) $(MgFe)_7Si_8O_{22}(OH)_2$;
(7) $CaO-3(MgFe)O-4SiO_2$
- **Synonyms:** (1) Asbestos fiber, serpentine, amphibole;
(2) Canadian chrysotile, white asbestos, serpentine;
(3) Brown asbestos, fibrous grunerite;
(4) Blue asbestos;
(5) Fibrous tremolite;
(6) Azbolen asbestos;
(7) Not available
- **Identifiers:** (1) CAS 1332-21-4; RTECS CI6475000; DOT 2212 (blue) 2590 (white);
(2) CAS 12001-29-5; RTECS CI6478500; DOT 2590;
(3) CAS 12172-73-5; RTECS CI6477000; DOT Not assigned;
(4) CAS 12001-28-4, RTECS CI6479000; DOT 2212;
(5) CAS 14567-73-8; RTECS CI6560000; DOT Not assigned;
(6) CAS 17068-78-9; RTECS CI6478000; DOT Not assigned;
(7) CAS 13768-00-8; RTECS CI6476000; DOT Not assigned
- **Appearance and odor:** A fiber or filament, asbestos may have a "fluffy" appearance. Colors may vary from white, gray, blue, brown, green or yellow. Positive identification requires microscopic examination.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: (2) 277.13; (5) 185.03
2. Specific gravity (water = 1): 2.5-3.0
3. Noncombustible solid

- **Warning properties**

Evaluation of warning properties for respirator selection: Warning properties are not considered in recommending respirators for use with carcinogens.

EXPOSURE LIMITS

Only asbestos fibers greater than 5 micrometers (μ)m in length are considered for the following exposure limits. The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for asbestos is 0.2 fiber per cubic centimeter (cc) of air as a time-weighted average (TWA) concentration over an 8-hour workshift with an action level of 0.1 fiber/cc as an hour TWA. The National Institute for Occupational Safety and Health (NIOSH) recommends that asbestos be controlled and handled as a potential human carcinogen in the workplace and that exposure be minimized to the lowest feasible limit. The NIOSH recommended exposure limit (REL) is 0.1 fiber/cc (in 40-liter air sample) as a TWA concentration for up to an 8-hour workshift, 40-hour workweek. The American Conference of Governmental Industrial Hygienists (ACGIH) has designated asbestos as an A1 substance (suspected human carcinogen, with an assigned threshold limit value/ TLV®) of 2 fibers/cc for chrysotile, 0.5 fiber/cc for amosite, 0.2 fiber/cc for crocidolite, and 2 fibers/cc for other forms, as a TWA for a normal 8-hour workday and a 40-hour workweek (Table 1).

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service   Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

Table 1.—Occupational exposure limits for asbestos

	Exposure limits mg/m³*
OSHA PEL TWA	0.2
Action level	0.1
NIOSH REL TWA (Ca)†	0.1
ACGIH TLV® TWA (A1a)§	
Chrysotile	2.0
Amosite	0.5
Crocidolite	0.2
Other forms	2.0

* Fibers greater than 5 μm in length.

† (Ca): NIOSH recommends treating as a potential human carcinogen.

§ (A1a): Human carcinogen with an assigned TLV®.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Asbestos may cause adverse health effects following exposure via inhalation or ingestion.

- **Summary of toxicology**

1. *Effects on animals:* Single intrapleural injections of asbestos in rats, rabbits, and hamsters produced mesothelioma (cancer of the chest or abdominal linings). In rats, chronic inhalation or oral administration of asbestos produced cancers of the lungs, stomach, kidneys, liver, or mammary glands. All forms of asbestos were found to be carcinogenic in treated animals.
2. *Effects on humans:* Exposure to asbestos has been found to significantly increase the risks of contracting asbestosis, lung cancer, and mesothelioma.

- **Signs and symptoms of exposure**

1. *Short-term (acute):* Exposure to asbestos can cause shortness of breath, chest or abdominal pain, and irritation of the skin and mucous membranes.
2. *Long-term (chronic):* Exposure to asbestos can cause reduced pulmonary function, breathing difficulty, dry cough, broadening and thickening of the ends of the fingers, and bluish discoloration of the skin and mucous membranes.

RECOMMENDED MEDICAL PRACTICES

- **Medical surveillance program**

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, and morbidity and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

- **Preplacement medical evaluation**

Prior to placing a worker in a job with a potential for exposure to asbestos, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the respiratory system using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to asbestos at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include cigarette smoking, preexisting asbestos-related disease, and significant breathing impairment due to preexisting chronic lung diseases. In addition to the medical interview and physical examination, the means to identify these conditions may include the methods recommended by NIOSH and ATS.

- **Periodic medical screening and/or biologic monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to asbestos. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the physiologic function of the respiratory system as compared to the baseline status of the individual worker or to the expected values for a suitable reference population. The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and ATS: standardized questionnaires, tests of lung function, and chest X-rays.

- **Medical practices recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population. Because occupational exposure to asbestos may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.

- **Sentinel health events**

Delayed-onset SHE's include: Scarring of the lungs (asbestosis) and its lining (pleural fibrosis) and cancer of the lungs (bronchogenic lung cancer) and its lining (mesothelioma).

MONITORING AND MEASUREMENT PROCEDURES

- **TWA exposure evaluation**

Measurements to determine worker exposure to asbestos should be taken so that the TWA exposure is based on a single entire workshift sample or an appropriate number of consecutive samples collected during the entire workshift. Under certain conditions, it may be appropriate to collect several short-term interval samples (up to 30 minutes each) to determine the average exposure level. Air samples should be taken in the worker's breathing zone (air that most nearly represents that inhaled by the worker).

- **Method**

Sampling and analysis for airborne asbestos may be performed by collecting asbestos fibers with membrane filters and analyzing by phase contrast microscopy. A detailed sampling and analytical method for asbestos may be found in the *NIOSH Manual of Analytical Methods* (method number 7400).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, and other appropriate protective clothing necessary to prevent skin contact with asbestos.

SANITATION

Clothing which is contaminated with asbestos should be removed at the end of the work period and placed in nonreusable, impermeable containers for storage, transport, and disposal until it can be discarded or until provision is made for the removal of asbestos from the clothing. These containers should be marked "Asbestos-Contaminated Clothing" in easy-to-read letters. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of asbestos's hazardous properties. Reusable clothing and equipment should be checked for residual contamination before reuse or storage.

A change room with showers, washing facilities, and lockers that permit separation of street and work clothes should be provided.

Workers should be required to shower following a workshift and prior to putting on street clothes. Clean work clothes should be provided daily.

Skin that becomes contaminated with asbestos should be promptly washed with soap and water.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or smoking of tobacco or other smoking materials, or the storage or use of products for chewing should be prohibited in work areas.

Workers who handle asbestos should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to asbestos may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for asbestos

Operations	Controls
During asbestos removal	Process enclosure, wet process (when possible), personal protective equipment
During the production of asbestos or the manufacture of products containing asbestos	Process enclosure, local exhaust ventilation, wet process (when possible), personal protective equipment
During the demolition of buildings	Water spray, personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

- **Eye exposure**

Where there is any possibility of a worker's eyes being exposed to asbestos, an eye wash fountain should be provided within the immediate work area for emergency use.

If asbestos gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this substance.

- **Skin exposure**

If asbestos gets on the skin, wash it immediately with soap and water.

- **Rescue**

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If asbestos is spilled or leaked, the following steps should be taken:

Asbestos dust may be collected by vacuuming with an appropriate high-efficiency filtration system or by using wet methods and placed in an appropriate container.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

BIBLIOGRAPHY

- American Conference of Governmental Industrial Hygienists: "Asbestos," *Documentation of the Threshold Limit Values and Biological Exposure Indices* (5th ed.), Cincinnati, 1986.
- American Conference of Governmental Industrial Hygienists: *TLVs® Threshold Limit Values and Biological Exposure Indices for 1987-88*, Cincinnati, 1987.
- American Lung Association of San Diego and Imperial Counties: "Taking the Occupational History," *Annals of Internal Medicine*, 99:641-651, November 1983.
- Clayton, G.D., and Clayton, F.E. (eds.): *Toxicology*, Vol. IIB of *Patty's Industrial Hygiene and Toxicology* (3rd rev. ed.), John Wiley & Sons, Inc., New York, 1981.
- *Code of Federal Regulations*, U.S. Department of Labor, Occupational Safety and Health Administration, 29 CFR 1910.1001, OSHA 2206, revised July 1, 1986.
- *Code of Federal Regulations*, U.S. Department of Transportation, 49 CFR 172.101, Transportation 49, revised October 1, 1982.
- Goldman, R.H., and Peters, J.M.: "The Occupational and Environmental Health History," *Journal of the American Medical Association*, 246:2831-2836, 1981.
- Halperin, W.E., Ratcliffe, J., Frazier, T.M., Wilson, L., Becker, S.P., and Shulte, P.A.: "Medical Screening in the Workplace: Proposed Principles," *Journal of Occupational Medicine*, 28(8): 547-552, 1986.
- Hankinson, J.L.: "Pulmonary Function Testing in the Screening of Workers: Guidelines for Instrumentation, Performance, and Interpretation," *Journal of Occupational Medicine*, 28(10):1081-1092, 1986.
- Hawley, G.G.: *The Condensed Chemical Dictionary* (10th ed.), Litton Educational Publishing, Inc., New York, 1981.
- International Agency for Research on Cancer: *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Some Inorganic and Organometallic Compounds*, Vol. 2, Lyon, France, 1973.
- International Agency for Research on Cancer: *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Asbestos*, Vol. 14, Lyon, France, 1977.
- Leidel, N.A., Busch, K.A., and Lynch, J.R.: *Occupational Exposure Sampling Strategy Manual*, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-173, Cincinnati, 1977.
- Lemen, R.A., Director, Division of Standards Development and Technology Transfer, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *Congressional Testimony before the Subcommittee on Public Buildings and Grounds, Committee on Public Works and Transportation, U.S. House of Representatives*, March 21, 1984.
- Levy, B.S., and Wegman, D.H. (eds.): *Occupational Health: Recognizing and Preventing Work-Related Disease*, Little, Brown and Company, Boston, 1983.
- Mark, H.F., Othmer, D.F., Overberger, C.G., Seaborg, G.T., Grayson, M., and Eckroth, D. (eds.): *Kirk-Othmer Encyclopedia of Chemical Technology* (3rd ed.), John Wiley & Sons, Inc., New York, 1978.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: *Criteria for a Recommended Standard. . . .Occupational Exposure to Asbestos*, HSM Publication No. (NIOSH) 72-10267, 1972.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: "Current Intelligence Bulletin 5, Asbestos Exposure During Servicing of Motor Vehicle Brake and Clutch Assemblies," *Current Intelligence Bulletin Reprints—Bulletins 1 thru 18*, DHEW (NIOSH) Publication No. 78-127, 1978.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: *Occupational*

Diseases—A Guide to their Recognition (rev. ed. 2nd printing), DHEW (NIOSH) Publication No. 77-181, 1978.

- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: *Revised Recommended Asbestos Standard*, DHEW (NIOSH) Publication No. 77-169, 1976.
- National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *NIOSH Manual of Analytical Methods* (3rd ed., Vol. 1), Eller, P.M. (ed.), DHHS (NIOSH) Publication No. 84-100, Cincinnati, 1984.
- National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *NIOSH Testimony to DOL, Statement of the National Institute for Occupational Safety and Health, The Public Hearing on Occupational Exposure to Asbestos*, Public Docket No. H-033C, June 21, 1984.
- National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *Registry of Toxic Effects of Chemical Substances* (Microfiche Edition), Sweet, D.V., and Lewis, R.J. (eds.), Cincinnati, April 1985.
- National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *Workplace Exposure to Asbestos, Review and Recommendations*, NIOSH-OSHA Asbestos Work Group, DHHS (NIOSH) Publication No. 81-103, 1980.
- Proctor, N.H., and Hughes, J.P.: *Chemical Hazards of the Workplace*, J.B. Lippincott Company, Philadelphia, 1978.
- Rom, W.N. (ed.): *Environmental and Occupational Medicine*, Little, Brown and Company, Boston, 1983.
- Rothstein, M.A.: *Medical Screening of Workers*, Bureau of National Affairs, Washington, DC, 1984.
- Rutstein, D.D., Mullan, R.J., Frazier, T.M., Halperin, W.E., Melius, J.M., and Sestito, J.P.: "Sentinel Health Events (Occupational): A Basis for Physician Recognition and Public Health Surveillance," *American Journal of Public Health*, 73:1054-1062, 1983.
- Scientific Assembly on Environmental and Occupational Health: "Evaluation of Impairment/Disability Secondary to Respiratory Disease," *American Review of Respiratory Diseases*, 126: 945-951, 1982.
- Scientific Assembly on Environmental and Occupational Health: "Proposed Guidelines for Case Evaluation (of Asbestos-Associated Diseases) Based on Assessment of Evidence Available March 1983," *American Thoracic Society News*, Fall 1983.
- Scientific Assembly on Environmental and Occupational Health: "Surveillance for Respiratory Hazards in the Occupational Setting," *American Review of Respiratory Diseases*, 126:952-956, 1982.

Table 3.—Respiratory protection for asbestos

Condition	Minimum respiratory protection*
Any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown or any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator with a high-efficiency particulate filter
	Any appropriate escape-type self-contained breathing apparatus

* Only NIOSH/MSHA-approved equipment should be used.

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR BENZENE

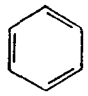
POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

This guideline summarizes pertinent information about benzene for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

- **Formula:** C_6H_6
- **Structure:**



- **Synonyms:** Benzol, benzole, benzolene, bicarburet of hydrogen, carbon oil, coal naphtha
- **Identifiers:** CAS 71-43-2; RTECS CY1400000; DOT 1114, label required: "Flammable Liquid"
- **Appearance and odor:** Colorless liquid with an aromatic odor

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 78.12
2. Boiling point (at 760 mmHg): 80.1°C (176°F)
3. Specific gravity (water = 1): 0.88
4. Vapor density (air = 1 at boiling point of benzene): 2.7
5. Melting point: 5.5°C (42°F)
6. Vapor pressure at 20°C (68°F): 75 mmHg
7. Solubility in water, g/100 g water at 20°C (68°F): 0.06
8. Evaporation rate (butyl acetate = 1): 5.1
9. Saturation concentration in air (approximate) at 25°C (77°F): 12.5% (125,000 ppm)
10. Ionization potential: 9.25 eV

- **Reactivity**

1. Incompatibilities: Benzene reacts with strong oxidizers including chlorine, oxygen, and bromine with iron.
2. Hazardous decomposition products: Toxic vapors and gases (e.g., carbon monoxide) may be released in a fire involving benzene.
3. Caution: Benzene will attack some forms of plastics, coatings, and rubber.

- **Flammability**

1. Flash point: -11.1°C (12°F) (closed cup)
2. Autoignition temperature: 498°C (928°F)
3. Flammable limits in air, % by volume: Lower, 1.4; upper, 7.1
4. Extinguishant: Alcohol foam, carbon dioxide, and dry chemical extinguishants are effective. Water may be an ineffective extinguishant but may be used to cool fire-exposed containers.
5. Class IB Flammable Liquid (29 CFR 1910.106), Flammability Rating 3 (NFPA)
6. Unusual fire and explosion hazards: Benzene liquid is flammable, and its vapors can easily form explosive mixtures. Flashbacks may occur along a vapor trail.

- **Warning properties**

1. Odor threshold: 12 ppm
2. Eye irritation levels: 3,000 ppm for 0.5-1 hour
3. Other information: 3,000 ppm may irritate nose and respiratory tract.
4. Evaluation of warning properties for respirator selection: Warning properties are not considered in recommending respirators for use with carcinogens.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for benzene is 1 part of benzene per million parts of air (PPM) as a time-weighted average (TWA) concentration over an 8-hour workshift; the short-term exposure limit is 5 ppm in any 15-minute sampling period. The National Institute for Occupational Safety and Health (NIOSH) recommends that benzene be controlled and handled as a potential human carcinogen in the workplace and that exposure be reduced to the lowest feasible limit. The NIOSH recommended exposure limit (REL) is 0.1 ppm [0.32 milligrams of benzene per cubic meter of air (mg/m^3)] as an 8-hour TWA and 1 ppm (3.2 mg/m^3) as a ceiling in any 15-minute sampling period. The NIOSH REL is the lowest con-

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

centration detectable by current NIOSH-validated sampling and analytical methods. The American Conference of Governmental Industrial Hygienists (ACGIH) has designated benzene as an A2 substance (suspected human carcinogen) having an assigned threshold limit value (TLV®) of 10 ppm (30 mg/m³) as a TWA for a normal 8-hour workday and a 40-hour workweek.

Table 1.—Occupational exposure limits for benzene

	Exposure limits	
	ppm	mg/m³
OSHA PEL TWA	1	—
Short-term exposure limit (15 min)	5	—
NIOSH REL (Ca)* TWA	0.1	0.32
Ceiling (15 min)	1	3.2
ACGIH TLV® TWA (A2)†	10	30

* (Ca): NIOSH recommends treating as a potential human carcinogen.
†(A2): Suspected human carcinogen.

HEALTH HAZARD INFORMATION

• Routes of exposure

Benzene may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.

• Summary of toxicology

1. *Effects on animals:* Acute inhalation of benzene by rats, mice, or rabbits caused narcosis, spontaneous heart contractions (ventricular fibrillation), and death due to respiratory paralysis. Subchronic inhalation of benzene by rats produced decreased white blood cell counts, decreased bone marrow cell activity, increased red blood cell activity, and cataracts. In rats, chronic inhalation or oral administration of benzene produced cancers of the liver, mouth, and Zymbal gland. Inhalation of benzene by pregnant rats caused retardation of fetal development and increased fetal mortality.
2. *Effects on humans:* Acute inhalation exposure of benzene has caused nerve inflammation (polyneuritis), central nervous system depression, and cardiac sensitization. Chronic exposure to benzene has produced anorexia and irreversible injury to the blood-forming organs; effects include aplastic anemia and leukemia.

• Signs and symptoms of exposure

1. *Short-term (acute):* Exposure to benzene can cause dizziness, euphoria, giddiness, headache, nausea, staggering gait, weakness, drowsiness, respiratory irritation, pulmonary edema and pneumonia, gastrointestinal irritation, convulsions, and paralysis. Benzene can also cause irritation to the skin, eyes, and mucous membranes.
2. *Long-term (chronic):* Exposure to benzene can cause fatigue, nervousness, irritability, blurred vision, and labored breathing. Repeated skin contact can cause redness, blistering, and dry, scaly dermatitis.

RECOMMENDED MEDICAL PRACTICES

• Medical surveillance program

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• Preplacement medical evaluation

Prior to placing a worker in a job with a potential for exposure to benzene, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the eyes, skin, liver, and respiratory, nervous, and hematopoietic (blood-cell-forming) systems. The physician should obtain baseline values for the complete blood count and a stained differential count of all blood cell types. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to benzene at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include a history of chronic skin disease, concurrent dermatitis, or mild non-hemolytic anemia (e.g., mild iron-deficiency anemia).

- **Periodic medical screening and/or biologic monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker report symptoms that may be attributed to exposure to benzene. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the integrity and physiologic function of the skin, liver, and respiratory, nervous, and hematopoietic (blood-cell-forming) systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and the ATS: standardized questionnaires and tests of lung function.

- **Medical practices recommended at the time of job transfer or termination.**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population. Because occupational exposure to benzene may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.

- **Sentinel health events**

1. Acute SHE's include: Acute myeloid leukemia and contact and/or allergic dermatitis.
2. Delayed-onset SHE's include: Decrease in the number (neutropenia) or absence (agranulocytosis) of certain white blood cells in the peripheral circulation and/or in the bone marrow (aplastic anemia) and cancer of the red blood cells (erythroleukemia).

MONITORING AND MEASUREMENT PROCEDURES

- **TWA exposure evaluation**

Measurements to determine worker exposure to benzene should be taken so that the TWA exposure is based on a single entire workshift sample or an appropriate number of consecutive samples collected during the entire workshift. Under certain conditions, it may be appropriate to collect several short-term interval samples (up to 30 minutes each) to determine the average exposure level. Air samples should be taken in the worker's breathing zone (air that most nearly represents that inhaled by the worker).

- **Ceiling concentration evaluation**

Measurements to determine worker exposure should be taken during periods of maximum expected airborne concentrations of benzene. Each measurement to determine the NIOSH REL (ceiling exposure) in the worker's breathing zone (air that most nearly represents that inhaled by the worker) should consist of a 15-minute sample. A minimum of three measurements should be taken during one workshift, and the highest of all measurements taken is an estimate of the worker's exposure. If the periods of maximum exposure are not clearly defined, a statistical procedure which can be used as a peak exposure detection strategy is given in the *Occupational Exposure Sampling Strategy Manual*.

- **Method**

Sampling and analysis may be performed by collecting benzene vapors with charcoal tubes followed by desorption with carbon disulfide and analysis by gas chromatography. Direct-reading devices calibrated to measure benzene may also be used if available. A detailed sampling and analytical method for benzene may be found in the *NIOSH Manual of Analytical Methods* (method number 1500).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, and other appropriate protective clothing necessary to prevent skin contact with benzene.

SANITATION

Clothing which is contaminated with benzene should be removed immediately and placed in sealed containers for storage until it can be discarded or until provision is made for the removal of benzene from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of benzene's hazardous properties. Reusable clothing and equipment should be checked for residual contamination before reuse or storage.

A change room with showers, washing facilities, and lockers that permit separation of street and work clothes should be provided.

Workers should be required to shower following a workshift and prior to putting on street clothes. Clean work clothes should be provided daily.

Skin that becomes contaminated with benzene should be promptly washed with soap and water.

Workers who handle benzene should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or use of smoking materials, or the storage or use of products for chewing should be prohibited in work areas.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to benzene may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for benzene

Operations	Controls
During the manufacture and processing of benzene; during use as a raw material in the production of aromatic compounds and derivatives	Process enclosure, local exhaust ventilation, personal protective equipment
During the use of chemicals in which benzene may be an impurity (e.g., naphthas, toluene, xylene)	Process enclosure, local exhaust ventilation, personal protective equipment
During the manufacture and use of motor fuel blends in which benzene is used as an ingredient; during use as an extracting solvent	Process enclosure (when possible), local exhaust ventilation, personal protective equipment, material substitution
During the preparation and use of paint and varnish removers, rubber cements, and lacquers	Process enclosure (when possible), local exhaust ventilation, personal protective equipment, material substitution

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

- Eye exposure

Where there is any possibility of a worker's eyes being exposed to benzene, an eye-wash fountain should be provided within the immediate work area for emergency use.

If benzene gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

- Skin exposure

Where there is any possibility of a worker's body being exposed to benzene, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If benzene gets on the skin, wash it immediately with soap and water. If benzene penetrates the clothing, remove the clothing immediately and wash the skin with soap and water. Get medical attention promptly.

- Rescue

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If benzene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities of liquids containing benzene, absorb on paper towels and place in an appropriate container.
4. Large quantities of liquids containing benzene may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container.
5. Liquids containing benzene may be collected by vacuuming with an appropriate system. If a vacuum system is used, there should be no sources of ignition in the vicinity of the spill, and flashback prevention devices should be provided.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards, 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

BIBLIOGRAPHY

- American Conference of Governmental Industrial Hygienists: *TLVs® Threshold Limit Values and Biological Exposure Indices for 1987-88*, Cincinnati, 1987.
- American Industrial Hygiene Association: "Benzene" (rev. 1978), *Hygienic Guide Series*, Detroit, 1978.
- American Lung Association of San Diego and Imperial Counties: "Taking the Occupational History," *Annals of Internal Medicine*, 99:641-651, November 1983.
- Amoore, J.E., and Hautala, E.: "Odor as a Chemical Safety Factor: Odor Thresholds Compared with Threshold Limit Values and Volatilities for 214 Industrial Chemicals in Air and Water Dilution," *Journal of Applied Toxicology*, 3:272-290, 1983.
- Baier, E.J., Deputy Director, National Institute for Occupational Safety and Health, Center for Disease Control, Public Health Service, Department of Health, Education, and Welfare: *Statement before the Department of Labor, Occupational Safety and Health, Public Hearing on the Occupational Standard for Benzene*, July 25-26, 1977.
- Clayton, G.D., and Clayton, F.E. (eds.): *Toxicology*, Vol. IIB of *Patty's Industrial Hygiene and Toxicology* (3rd rev. ed.), John Wiley & Sons, Inc., New York, 1981.
- *Code of Federal Regulations*, U.S. Department of Labor, Occupational Safety and Health Administration, 29 CFR 1910.106, 1910.134, 1910.1000, OSHA 2206, revised July 1, 1986.
- *Code of Federal Regulations*, U.S. Department of Transportation, 49 CFR 172.101, Transportation 49, revised October 1, 1982.
- Goldman, R.H., and Peters, J.M.: "The Occupational and Environmental Health History," *Journal of the American Medical Association*, 246:2831-2836, 1981.
- Halperin, W.E., Ratcliffe, J., Frazier, T.M., Wilson, L., Becker, S.P., and Shulte, P.A.: "Medical Screening in the Workplace: Proposed Principles," *Journal of Occupational Medicine*, 28(8):547-552, 1986.
- Hankinson, J.L.: "Pulmonary Function Testing in the Screening of Workers: Guidelines for Instrumentation, Performance, and Interpretation," *Journal of Occupational Medicine*, 28(10):1081-1092, 1986.
- Hawley, G.G.: *The Condensed Chemical Dictionary* (10th ed.), Litton Educational Publishing Inc., New York, 1981.
- International Agency for Research on Cancer: *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Some Industrial Chemicals and Dyestuffs*, Vol. 29, Lyon, France, 1982.
- Leidel, N.A., Busch, K.A., and Lynch, J.R.: *Occupational Exposure Sampling Strategy Manual*, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-173, Cincinnati, 1977.
- Levy, B.S., and Wegman, D.H. (eds.): *Occupational Health: Recognizing and Preventing Work-Related Disease*, Little, Brown and Company, Boston, 1983.
- National Fire Protection Association: *National Fire Codes®*, (Vol. 13), Quincy, Massachusetts, 1983.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: *Criteria for a Recommended Standard.... Occupational Exposure to Benzene*, HSM (NIOSH) Publication No. 74-137, Cincinnati, 1974.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: *Revised Recommendation for an Occupational Exposure Standard for Benzene*, Cincinnati, 1976.
- National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *NIOSH Manual of Analytical Methods* (3rd ed., Vol. 1), Eller, P.M. (ed.), DHHS (NIOSH) Publication No. 84-100, Cincinnati, 1984.
- National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *Registry of Toxic Effects of Chemical Substances* (Microfiche Edition), Sweet, D.V., and Lewis, R.J. (eds.), Cincinnati, April 1985.
- Proctor, N.H., and Hughes, J.P.: *Chemical Hazards of the Workplace*, J.B. Lippincott Company, Philadelphia, 1978.
- Rom, W.N. (ed.): *Environmental and Occupational Medicine*, Little, Brown and Company, Boston, 1983.
- Rothstein, M.A.: *Medical Screening of Workers*, Bureau of National Affairs, Washington, DC, 1984.
- Rutstein, D.D., Mullan, R.J., Frazier, T.M., Halperin, W.E., Melius, J.M., and Sestito, J.P.: "Sentinel Health Events (Occupational): A Basis for Physician Recognition and Public Health Surveillance," *American Journal of Public Health*, 73:1054-1062, 1983.
- Sax, N.I. (ed.): *Dangerous Properties of Industrial Materials* (6th ed.), Van Nostrand Reinhold Company, New York, 1984
- U.S. Department of Transportation, Coast Guard: *CHRIS Hazardous Chemical Data*, GPO Stock No. 050-012-00147-2, 1978.
- Weast, R.C. (ed.): *CRC Handbook of Chemistry and Physics* (64th ed.), CRC Press, Inc., Boca Raton, Florida, 1983.
- Windholz, M. (ed.): *The Merck Index* (10th ed.), Merck & Co., Inc., Rahway, New Jersey, 1983.

Occupational Health Guideline for Coal Tar Pitch Volatiles

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

Anthracene

- Formula: $C_{14}H_{10}$
- Synonyms: None
- Appearance and odor: Pale green solid with a faint aromatic odor.

Phenanthrene

- Formula: $C_{14}H_{10}$
- Synonyms: None
- Appearance and odor: Colorless solid with a faint aromatic odor.

Pyrene

- Formula: $C_{16}H_{10}$
- Synonyms: None
- Appearance: Bright yellow solid

Carbazole

- Formula: $C_{12}H_9N$
- Synonyms: None
- Appearance and odor: Colorless solid with a faint aromatic odor.

Benzo(a)pyrene

- Formula: $C_{20}H_{12}$
- Synonyms: BaP, 3,4-benzopyrene
- Appearance and odor: Colorless solid with a faint aromatic odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for coal tar pitch volatiles is 0.2 milligram of coal tar pitch volatiles per cubic meter of air (mg/m^3) averaged over an eight-hour work shift. NIOSH has recommended that the permissible exposure limit for coal tar products be reduced to 0.1 mg/m^3 (cyclohexane-extractable fraction) averaged over a work shift of up to 10 hours per day, 40 hours per week, and that coal tar products be regulated as occupational carcinogens. The NIOSH Criteria Document for Coal Tar Products and NIOSH Criteria Document for Coke Oven Emissions should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Coal tar pitch volatiles can affect the body if they are inhaled or if they come in contact with the eyes or skin.

- **Effects of overexposure**

Repeated exposure to coal tar pitch volatiles has been associated with an increased risk of developing bronchitis and cancer of the lungs, skin, bladder, and kidneys. Pregnant women may be especially susceptible to exposure effects associated with coal tar pitch volatiles. Repeated exposure to these materials may also cause sunlight to have a more severe effect on a person's skin. In addition, this type of exposure may cause an allergic skin rash.

- **Reporting signs and symptoms**

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to coal tar pitch volatiles.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to coal tar pitch volatiles at potentially hazardous levels:

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the oral cavity, respiratory tract, bladder, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders, for premalignant and malignant lesions, and evidence of hyperpigmentation or photosensitivity.

—Urinalysis: Coal tar pitch volatiles are associated with an excess of kidney and bladder cancer. A urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment, as well as a test for red blood cells.

—Urinary cytology: Coal tar pitch volatiles are associated with an excess of kidney and bladder cancer. Employees having 5 or more years of exposure or who are 45 years of age or older should have a urinary cytology examination.

—Sputum cytology: Coal tar pitch volatiles are associated with an excess of lung cancer. Employees having 10 or more years of exposure or who are 45 years of age or older should have a sputum cytology examination.

—14" x 17" chest roentgenogram: Coal tar pitch volatiles are associated with an excess of lung cancer. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Coal tar pitch volatiles are reported to cause an excess of bronchitis. Periodic surveillance is indicated.

—A complete blood count: Due to the possibility of benzene exposure associated with coal tar pitch volatiles, a complete blood count is considered necessary to search for leukemia and aplastic anemia.

—Skin disease: Coal tar pitch volatiles are defatting agents and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of these agents.

2. *Periodic Medical Examination:* The aforementioned medical examinations should be repeated on an annual basis, and semi-annually for employees 45 years of age or older or with 10 or more years' exposure to coal tar pitch volatiles.

- Summary of toxicology

Coal tar pitch volatiles (CTPV) are products of the destructive distillation of bituminous coal and contain polynuclear aromatic hydrocarbons (PNA's). These hydrocarbons sublime readily, thereby increasing the amounts of carcinogenic compounds in working areas. Epidemiologic evidence suggests that workers intimately exposed to the products of combustion or distillation of bituminous coal are at increased risk of cancer at many sites. These include cancer of the respiratory tract, kidney, bladder, and skin. In a study of coke oven workers, the level of exposure to CTPV and the length of time exposed were related to the development of cancer. Coke oven workers with the highest risk of cancer were those employed exclusively at topside jobs for 5 or more years, for whom the increased risk of dying from lung cancer was 10-fold; all coke oven workers had a 7-½-fold increase in risk of dying from kidney cancer. Although the causative agent or agents of the cancer in coke oven workers is unidentified, it is suspected that several PNA's in the CTPV generated during the coking process are involved. Certain industrial populations exposed to coal tar products have a demonstrated risk of skin cancer. Substances containing PNA's which may produce skin cancer also produce contact dermatitis; examples are coal tar, pitch, and cutting oils. Although allergic dermatitis is readily induced by PNA's in guinea pigs, it is only rarely reported in humans from occupational contact with PNA's; these have resulted largely from the therapeutic use of coal tar preparations. Components of pitch and coal tar produce cutaneous photosensitization; skin eruptions are usually limited to areas exposed to the sun or ultraviolet light. Most of the phototoxic agents will induce hypermelanosis of the skin; if chronic photodermatitis is severe and prolonged, leukoderma may occur. Some oils containing PNA's have been associated with changes of follicular and sebaceous glands which commonly take the form of acne. There is evidence that exposures to emissions at coke ovens and gas retorts may be associated with an increased occurrence of chronic bronchitis. Coal tar pitch volatiles may be associated with benzene, an agent suspected of causing leukemia and known to cause aplastic anemia.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data—Anthracene**
  1. Molecular weight: 178.2
  2. Boiling point (760 mm Hg): 340 C (644 F)
  3. Specific gravity (water = 1): 1.24
  4. Vapor density (air = 1 at boiling point of anthracene): 6.15
  5. Melting point: 217 C (423 F)
  6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
  8. Evaporation rate (butyl acetate = 1): Not applicable
- **Physical data—Phenanthrene**
  1. Molecular weight: 178.2
  2. Boiling point (760 mm Hg): 340 C (644 F)
  3. Specific gravity (water = 1): 1.18
  4. Vapor density (air = 1 at boiling point of phenanthrene): 6.15
  5. Melting point: 100.5 C (213 F)
  6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
  8. Evaporation rate (butyl acetate = 1): Not applicable
- **Physical data—Pyrene**
  1. Molecular weight: 202.3
  2. Boiling point (760 mm Hg): Greater than 360 C (greater than 680 F)

3. Specific gravity (water = 1): 1.28
4. Vapor density (air = 1 at boiling point of pyrene): 6.9
5. Melting point: 150.4 C (303 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Carbazole**

1. Molecular weight: 167.2
2. Boiling point (760 mm Hg): 355 C (671 F)
3. Specific gravity (water = 1): Greater than 1
4. Vapor density (air = 1 at boiling point of carbazole): 5.8
5. Melting point: 246 C (475 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Benzo(a)pyrene**

1. Molecular weight: 252.3
2. Boiling point (760 mm Hg): Greater than 360 C (greater than 680 F)
3. Specific gravity (water = 1): Greater than 1
4. Vapor density (air = 1 at boiling point of benzo(a)pyrene): 8.7
5. Melting point: 179 C (354 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Reactivity**

1. Conditions contributing to instability: None hazardous
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: None
4. Special precautions: None

- **Flammability**

1. Flash point: Anthracene: 121 C (250 F) (closed cup); Others: Data not available
2. Autoignition temperature: Anthracene: 540 C (1004 F); Others: Data not available
3. Flammable limits in air, % by volume: Anthracene: Lower: 0.6; Others: Data not available
4. Extinguishant: Foam, dry chemical, and carbon dioxide

- **Warning properties**

Grant states that "coal tar and its various crude fractions appear principally to cause reddening and squamous eczema of the lid margins, with only small erosions of the corneal epithelium and superficial changes in the stroma, which disappear in a month following exposure. Chronic exposure of workmen to tar fumes and dust has been reported to cause conjunctivitis and discoloration of the cornea in the palpebral fissure, either near the limbus or, in extreme cases, across the whole cornea. Occasionally, epithelioma of the lid margin has been attributed to contact with coal tar."

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Coal tar products may be sampled by collection on a glass fiber filter with subsequent ultrasonic extraction and weighing. An analytical method for coal tar pitch volatiles is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 1, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00267-3).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with condensed coal tar pitch volatiles, where skin contact may occur.
- If employees' clothing may have become contaminated with coal tar pitch volatiles, employees should change into uncontaminated clothing before leaving the work premises.
- Clothing contaminated with coal tar pitch volatiles

should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of coal tar pitch volatiles from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the coal tar pitch volatiles, the person performing the operation should be informed of coal tar pitch volatiles's hazardous properties.

- Employees should be provided with and required to use splash-proof safety goggles where condensed coal tar pitch volatiles may contact the eyes.

SANITATION

- Workers subject to skin contact with coal tar pitch volatiles should wash with soap or mild detergent and water any areas of the body which may have contacted coal tar pitch volatiles at the end of each work day.
- Employees who handle coal tar pitch volatiles should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.
- Areas in which exposure to coal tar pitch volatiles may occur should be identified by signs or other appropriate means, and access to these areas should be limited to authorized persons.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to coal tar pitch volatiles may occur and control methods which may be effective in each case:

Operation	Controls
Liberation from extraction and packaging from coal tar fraction of coking	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as a binding agent in manufacture of coal briquettes used for fuel; use as a dielectric in the manufacture of battery electrodes, electric-arc furnace electrodes, and electrodes for alumina reduction	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in manufacture of roofing felts and papers and roofing	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use for protective coatings for pipes for underground conduits and drainage; use as a coating on concrete as waterproofing and corrosion-resistant material; use in road paving and sealing	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in manufacture and repair of refractory brick; use in production of foundry cores; use in manufacture of carbon ceramic items	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If condensed coal tar pitch volatiles get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with these chemicals.

- **Skin Exposure**

If condensed coal tar pitch volatiles get on the skin, wash the contaminated skin using soap or mild detergent and water. Be sure to wash the hands before eating or smoking and to wash thoroughly at the close of work.

- **Breathing**

If a person breathes in large amounts of coal tar pitch volatiles, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of releases until cleanup has been completed.
- If coal tar pitch volatiles are released in hazardous concentrations, the following steps should be taken:

1. Ventilate area of spill.

2. Collect released material in the most convenient and safe manner for reclamation or for disposal in sealed containers in a secured sanitary landfill.

- Waste disposal method:

Coal tar pitch volatiles may be disposed of in sealed containers in a secured sanitary landfill.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Coal Tar Pitch Volatiles," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- Bingham, E.: "Environmental Carcinogens," *Archives of Environmental Health*, 19:779-85, DES 1969.
- Bingham, E.: "Thresholds in Cancer Inductions," *Archives of Environmental Health*, 22:692-95, June 1971.
- 'Coke Oven Emissions," *Federal Register*, 40:32268-32282, July 31, 1975.
- Committee on Biologic Effects of Atmospheric Pollutants, Division of Medical Sciences, National Research Council: *Particulate Polycyclic Organic Matter*, National Academy of Sciences, Washington, D.C., 1972.
- Fannick, N., et al.: "Exposure to Coal Tar Pitch Volatiles at Coke Ovens," *American Industrial Hygiene Association Journal*, 33:461-468, 1972.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- Hittle, D. C., and Stukel, J. J.: "Particle Size Distribution and Chemical Composition of Coal-Tar Fumes," *American Industrial Hygiene Association Journal*, 37:199-204, 1976.
- *Hygienic Information Guide No. 89 – Coal Tar Pitch Volatiles*, Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Occupational Health, 1972.
- International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1971.
- Lloyd, J. W.: "Long-Term Mortality Study of Steelworkers. V. Respiratory Cancer in Coke Plant Workers," *Journal of Occupational Medicine*, 13:53-68, 1971.
- Mazumdar, S., et al.: "An Epidemiological Study of Exposure to Coal Tar Pitch Volatiles among Coke Oven Workers," *Journal of the Air Pollution Control Association*, 25:382-389, 1975.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard .... Occupational Exposure to Coal Tar Products*, HEW Publication No. (NIOSH) 78-107, U.S. Government Printing Office, Washington, D.C., 1977.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard .... Occupational Exposure to Coke Oven Emissions*, HEW Publication No. HSM 73-11016, GPO No. 017-033-00015, U.S. Government Printing Office, Washington, D.C., 1973.
- Redmond, C. K., et al.: "Long-Term Mortality Study of Steelworkers. VI. Mortality from Malignant Neoplasms Among Coke Oven Workers," *Journal of Occupational Medicine*, 14:621-629, 1972.
- Scala, R. A.: "Toxicology of PPOM," *Journal of Occupational Medicine*, 17:784-788, 1975.
- Tye, R., and Stemmer, K. L.: "Experimental Carcinogenesis of the Lung. II. Influence of Phenols in the Production of Carcinoma," *Journal of the National Cancer Institute*, 39:175-179, 1967.

Occupational Health Guideline for 1,1-Dichloroethane

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: CH_3CHCl_2
- Synonyms: Asymmetrical dichloroethane; ethylidene chloride; 1,1-ethylidene dichloride
- Appearance and odor: Colorless liquid with a chloroform-like odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for 1,1-dichloroethane is 100 parts of 1,1-dichloroethane per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 400 milligrams of 1,1-dichloroethane per cubic meter of air (mg/m^3). The American Conference of Governmental Industrial Hygienists has recommended for 1,1-dichloroethane a Threshold Limit Value of 200 ppm.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

1,1-Dichloroethane can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

1. *Short-term Exposure:* Breathing 1,1-dichloroethane vapor may cause drowsiness and unconsciousness. It might also cause damage to the liver, kidneys, and lungs. Splashing the liquid in the eyes may cause irritation.

2. *Long-term Exposure:* Prolonged, confined, or repeated skin contact with 1,1-dichloroethane can produce a slight burn.

3. *Reporting Signs and Symptoms:* A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to 1,1-dichloroethane.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to 1,1-dichloroethane at potentially hazardous levels:

1. *Initial Medical Screening:* Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from 1,1-dichloroethane exposure.

—Skin disease: 1,1-Dichloroethane can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver disease: Although 1,1-dichloroethane is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although 1,1-dichloroethane is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of 1,1-dichloroethane might cause exacerbation of symptoms due to its irritant properties.

2. *Periodic Medical Examination:* Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

1,1-Dichloroethane vapor is a narcotic. Rats exposed to 32,000 ppm for 30 minutes did not survive. The most consistent findings in animals exposed to concentrations

---

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service   Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

of above 8,000 ppm for up to 7 hours were pathologic changes in the kidney and liver, and at much higher concentrations, near 64,000 ppm, damage to the lungs as well. Repeated daily exposure of several species of animals to 1,000 ppm resulted in no pathologic or hematologic changes. The liquid applied to the intact or abraded skin of rabbits produced slight edema and very slight necrosis after six daily applications. Instilled in the eyes of rabbits there was immediate, moderate conjunctival irritation and swelling which subsided within a week. There have been no reported cases of human overexposure by inhalation; prolonged, confined, or repeated skin contact can produce a slight burn.

CHEMICAL AND PHYSICAL PROPERTIES

- Physical data

1. Molecular weight: 99
2. Boiling point (760 mm Hg): 57.3 C (135 F)
3. Specific gravity (water = 1): 1.2
4. Vapor density (air = 1 at boiling point of 1,1-dichloroethane): 3.4
5. Melting point: −96.7 C (−142 F)
6. Vapor pressure at 20 C (68 F): 182 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Less than 0.1
8. Evaporation rate (butyl acetate = 1): 11.6

- Reactivity

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions. Contact with strong caustics will cause formation of flammable and toxic acetaldehyde gas.
3. Hazardous decomposition products: Toxic gases and vapors (such as vinyl chloride, hydrogen chloride, phosgene, and carbon monoxide) may be released in a fire involving 1,1-dichloroethane.
4. Special precautions: 1,1-Dichloroethane will attack some forms of plastics, rubber, and coatings.

- Flammability

1. Flash point: −8.5 C (17 F) (closed cup)
2. Autoignition temperature: Data not available
3. Flammable limits in air, % by volume: Lower: 5.9; Upper: 15.9
4. Extinguishant: Foam, dry chemical, carbon dioxide

- Warning properties

The AIHA *Hygienic Guide* reports that 1,1-dichloroethane has a distinctive, easily recognizable odor at the TLV.

1,1-Dichloroethane is not known to be an eye irritant.

MONITORING AND MEASUREMENT PROCEDURES

- General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure 1,1-dichloroethane may be used. An analytical method for 1,1-dichloroethane is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid 1,1-dichloroethane.
- Clothing wet with liquid 1,1-dichloroethane should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of 1,1-dichloroethane from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the 1,1-dichloroethane, the person performing the operation should be informed of 1,1-dichloroethane's hazardous properties.
- Any clothing which becomes wet with liquid 1,1-dichloroethane should be removed immediately and not

reworn until the 1,1-dichloroethane is removed from the clothing.

- Employees should be provided with and required to use splash-proof safety goggles where liquid 1,1-dichloroethane may contact the eyes.

SANITATION

- Skin that becomes wet with liquid 1,1-dichloroethane should be immediately washed or showered with soap or mild detergent and water to remove any 1,1-dichloroethane.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to 1,1-dichloroethane may occur and control methods which may be effective in each case:

Operation	Controls
Use as dewaxer of mineral oils; extractant for heat-sensitive substances	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a fumigant	General dilution ventilation of work area; personal protective equipment
Use in manufacture of vinyl chloride by vapor phase cracking; use in manufacture of high vacuum rubber and silicon grease; use as a chemical intermediate	General dilution ventilation; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If 1,1-dichloroethane gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If 1,1-dichloroethane gets on the skin, promptly flush the contaminated skin using soap or mild detergent and water. If 1,1-dichloroethane soaks through the clothing, remove the clothing immediately and flush the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

- **Breathing**

If a person breathes in large amounts of 1,1-dichloroethane, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Swallowing**

When 1,1-dichloroethane has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If 1,1-dichloroethane is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. 1,1-Dichloroethane should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of 1,1-dichloroethane vapors are permitted.

- Waste disposal method:

1,1-Dichloroethane may be disposed of by atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "1,1-Dichloroethane (Ethylidene Chloride)," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "1,1-Dichloroethane (Ethylidene Chloride)," *Hygienic Guide Series*, Detroit, Michigan, 1971.

- Browning, E.: *Toxicity and Metabolism of Industrial Solvents*, Elsevier, New York, 1965.
- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.
- Elkins, H. B.: *Chemistry of Industrial Toxicology* (2nd ed.), Wiley, New York, 1959.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- Kirk, R., and Othmer, D.: *Encyclopedia of Chemical Technology* (2nd ed.), Interscience, New York, 1968.
- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
- Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

RESPIRATORY PROTECTION FOR 1,1-DICHLOROETHANE

Condition	**Minimum Respiratory Protection* Required Above 100 ppm**
Vapor Concentration	
1000 ppm or less	Any chemical cartridge respirator with an organic vapor cartridge(s). Any supplied-air respirator. Any self-contained breathing apparatus.
4000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece. A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 4000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

ETHYLBENZENE

ETB

Common Synonyms
Phenylethane
EB

Liquid | Colorless | Sweet, gasoline-like odor

Floats on water. Flammable, irritating vapor is produced.

Avoid contact with liquid and vapor. Keep people away.
Wear goggles, self contained breathing apparatus, and rubber overclothing (including gloves)
Shut off ignition sources and call fire department.
Stop discharge if possible.
Stay upwind and use water spray to "knock down" vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves)
Extinguish with dry chemical, foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause dizziness or difficult breathing.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Will burn skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk
DO NOT INDUCE VOMITING.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
Fouling to shoreline
May be dangerous if it enters water intakes.

Notify local health and wildlife officials
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Mechanical containment
Should be removed
Chemical and physical treatment

2. LABEL

2.1 **Category:** Flammable liquid
2.2 **Class:** 3

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Aromatic hydrocarbon
3.2 **Formula:** $C_6H_5CH_2CH_3$
3.2 **IMO/UN Designation:** 3.3/1175
3.4 **DOT ID No.:** 1175
3.5 **CAS Registry No.:** 100-41-4

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Aromatic

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Self-contained breathing apparatus; safety goggles.
5.2 **Symptoms Following Exposure:** Inhalation may cause irritation of nose, dizziness, depression. Moderate irritation of eye with corneal injury possible. Irritates skin and may cause blisters.
5.3 **Treatment of Exposure:** INHALATION: if ill effects occur, remove victim to fresh air, keep him warm and quiet, and get medical help promptly; if breathing stops, give artificial respiration. INGESTION: induce vomiting only upon physician's approval; material in lung may cause chemical pneumonitis. SKIN AND EYES: promptly flush with plenty of water (15 min. for eyes) and get medical attention; remove and wash contaminated clothing before reuse.
5.4 **Threshold Limit Value:** 100 ppm
5.5 **Short Term Inhalation Limits:** 200 ppm for 30 min.
5.6 **Toxicity by Ingestion:** Grade 2; LD_{50} = 0.5 to 5 g/kg (rat)
5.7 **Late Toxicity:** Data not available
5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary.
5.9 **Liquid or Solid Irritant Characteristics:** Causes smarting of the skin and first-degree burns on short exposure, may cause secondary burns on long exposure.
5.10 **Odor Threshold:** 140 ppm
5.11 **IDLH Value:** 2,000 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 80°F O.C.; 59°F C.C.
6.2 **Flammable Limits in Air:** 1.0%-6.7%
6.3 **Fire Extinguishing Agents:** Foam (most effective), water fog, carbon dioxide or dry chemical.
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Irritating vapors are generated when heated.
6.6 **Behavior in Fire:** Vapor is heavier than air and may travel considerable distance to the source of ignition and flash back.
6.7 **Ignition Temperature:** 860°F
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** 5.8 mm/min.
6.10 **Adiabatic Flame Temperature:** Data Not Available

(Continued)

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent
7.7 **Molar Ratio (Reactant to Product):** Data Not Available
7.8 **Reactivity Group:** 32

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 29 ppm/96 hr/bluegill/TL_m/fresh water
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** 2.8% (theor.), 5 days
8.4 **Food Chain Concentration Potential:** None

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** Research grade: 99.96%; pure grade: 99.5%; technical grade: 99.0%
9.2 **Storage Temperature:** Ambient
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Open (flame arrester) or pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-T-U

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** Flammable liquid
11.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	2
Liquid or Solid Irritant	2
Poisons	2
Water Polution	
Human Toxicity	1
Aquatic Toxicity	1
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self Reaction	0

11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Liquid
12.2 **Molecular Weight:** 106.17
12.3 **Boiling Point at 1 atm:** 277.2°F = 136.2°C = 409.4°K
12.4 **Freezing Point:** −139°F = −95°C = 178°K
12.5 **Critical Temperature:** 651.0°F = 343.9°C = 617.1°K
12.6 **Critical Pressure:** 523 psia = 35.6 atm = 3.61 MN/m²
12.7 **Specific Gravity:** 0.867 at 20°C (liquid)
12.8 **Liquid Surface Tension:** 29.2 dynes/cm = 0.0292 N/m at 20°C
12.9 **Liquid Water Interfacial Tension:** 35.48 dynes/cm = 0.03548 N/m at 20°C
12.10 **Vapor (Gas) Specific Gravity:** Not pertinent
12.11 **Ratio of Specific Heats of Vapor (Gas):** 1.071
12.12 **Latent Heat of Vaporization:** 144 Btu/lb = 80.1 cal/g = 3.35×10^5 J/kg
12.13 **Heat of Combustion:** −17,790 Btu/lb = −9877 cal/g = -413.5×10^5 J/kg
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** Data Not Available
12.26 **Limiting Value:** Data Not Available
12.27 **Reid Vapor Pressure:** 0.4 psia

6. FIRE HAZARDS (Continued)

6.11 **Stoichiometric Air to Fuel Ratio:** Data Not Available
6.12 **Flame Temperature:** Data Not Available

LEAD SULFATE

LSF

Common Synonyms	Solid powder	White	Odorless
Anglesite Pigment white 3 Fast white Freeman's white lead Lanarkite Lead bottoms; milk white	Sinks in water.		

Avoid contact with solid and dust. Keep people away
Wear goggles, self contained breathing apperatus and rubber gloves.
Stop discharge if possible
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Not flammable.

Exposure

CALL FOR MEDICAL AID.

DUST OR SOLID
POISONOUS IF INHALED.
Irritating to eyes.
If swallowed will cause abdominal pain, nausea, vomiting, headache and muscular weakness.
Move to fresh air.
IF IN EYES, hold eyelids open and flush with plenty of water.
Flush affected areas with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk and induce vomiting.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Issue warning - water contaminant, corrosive.
Restrict access.
Should be removed.
Chemical and physical treatment.

2. LABEL

2.1 **Category:** Corrosive
2.2 **Class:** 8

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Not listed
3.2 **Formula:** $PbSO_4$
3.3 **IMO/UN Designation:** 8/1794 (only if substance contains more than 3% free acid)
3.4 **DOT ID No.:** 1794
3.5 **CAS Registry No.:** 7446-14-2

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Solid
4.2 **Color:** White
4.3 **Odor:** None

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Wear approved filter mask, rubber gloves, and safety glasses.
5.2 **Symptoms Following Exposure:** INHALATION: Joint and muscle pains, headache, dizziness and insomnia. Weakness, frequently of extensor muscles of hand and wrist (unilateral or bilateral). Heavy contamination. Brain damage. Stupor progressing to coma - with or without convulsion, often death. Excitation, confusion, and mania less common. Cerebrospinal pressure may be increased. EYES: Caused a moderat purulent reaction and general inflammation of the rabbit eye. INGESTION: Abdominal pain, diarrhea, constipation, loss of appetite, muscular weakness, headache, blue line on gums, metallic taste, nausea and vomiting.
5.3 **Treatment of Exposure:** Get medical aid. INHALATION: Remove from source of exposure and keep quiet. EYES: Wash with running water. SKIN: Wash with soap and water. INGESTION: Wash mouth, give emetic then epsom salts (30 g/250 ml hot water); get medical attention.
5.4 **Threshold Limit Value:** 0.15 mg/m^3
5.5 **Short Term Inhalation Limits:** 0.45 mg/m^3
5.6 **Toxicity by Ingestion:** Grade 3 LD50 = 50 to 500 mg/kg.
5.7 **Late Toxicity:** Intermittent vomiting, irritability, nervousness, incoordination, vague pains in the arms, legs, joints, and abdomen. Sensory disturbances of extremities, paralysis of extensor muscles of arms and legs with wrist and foot drop. Disturbance of menstrual cycle, and abortion. Periods of stupor or lethargy, encephalopathy (with visual disturbances), elevated blood pressure, papilledema, cranial nerve paralysis, delerium, convulsions, and coma.
5.8 **Vapor (Gas) Irritant Characteristics:** Data not available
5.9 **Liquid or Solid Irritant Characteristics:** Data not available
5.10 **Odor Threshold:** Not pertinent
5.11 **IDLH Value:** Data not available

6. FIRE HAZARDS

6.1 **Flash Point:** Not pertinent
6.2 **Flammable Limits in Air:** Not flammable
6.3 **Fire Extinguishing Agents:** Not pertinent
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Toxic metal fumes
6.6 **Behavior in Fire:** Not pertinent
6.7 **Ignition Temperature:** Not pertinent
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** Not flammable
6.10 **Adiabatic Flame Temperature:** Data not available
6.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** No reaction
7.2 **Reactivity with Common Materials:** Data not available
7.3 **Stability During Transport:** Data not available
7.4 **Neutralizing Agents for Acids and Caustics:** Data not available
7.5 **Polymerization:** Data not available
7.6 **Inhibitor of Polymerization:** Data not available
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** Data not available

8. WATER POLLUTION

8.1 **Aquatic Toxicity:**
25 ppm/96-hour/Goldfish/lethal concentration/distilled water
25 ppm/2-to 3-hour/Minnow/lethal concentration/distilled water
2.4 ppm/96-hour/Fathead minnow/TL_m/soft water
75 ppm/96-hour/Fathead minnow/TL_m/hard water
0.1 ppm/chronic aquatic toxicity limits
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** Data not available
8.4 **Food Chain Concentration Potential:** Fish and animal life are capable of lead concentration.

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** 83.2% to 88.7% PbO
9.2 **Storage Temperature:** Data not available
9.3 **Inert Atmosphere:** Data not available
9.4 **Venting:** Data not available

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

SS

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** Corrosive material
11.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed
11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	4
Flammability (Red)	0
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Solid
12.2 **Molecular Weight:** 303.28
12.3 **Boiling Point at 1 atm:** Data not available
12.4 **Freezing Point:** 2138°F = 1170°C = 1443.2°K
12.5 **Critical Temperature:** Data not available
12.6 **Critical Pressure:** Data not available
12.7 **Specific Gravity:** 6.2 at room temperature
12.8 **Liquid Surface Tension:** Not pertinent
12.9 **Liquid Water Interfacial Tension:** Not pertinent
12.10 **Vapor (Gas) Specific Gravity:** 10.46 (calculated)
12.11 **Ratio of Specific Heats of Vapor (Gas):** Not pertinent
12.12 **Latent Heat of Vaporization:** Data not available
12.13 **Heat of Combustion:** Not pertinent
12.14 **Heat of Decomposition:** Data not available
12.15 **Heat of Solution:** Data not available
12.16 **Heat of Polymerization:** Data not available
12.25 **Heat of Fusion:** 31.6 cal/g
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** Data not available

NOTES

Occupational Health Guideline for Methylene Chloride

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: CH_2Cl_2
- Synonyms: Dichloromethane; methylene dichloride
- Appearance and odor: Colorless liquid with an odor like chloroform.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for methylene chloride is 500 parts of methylene chloride per million parts of air (ppm) averaged over an eight-hour work shift, with an acceptable ceiling level of 1000 ppm and a maximum peak concentration of 2000 ppm for 5 minutes in any two-hour period. NIOSH has recommended that the permissible exposure limit be reduced to 75 ppm averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 500 ppm averaged over a 15-minute period. NIOSH further recommends that permissible levels of methylene chloride be reduced where carbon monoxide is present. The NIOSH Criteria Document for Methylene Chloride should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- Routes of exposure

Methylene chloride can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- Effects of overexposure

1. Short-term Exposure: Methylene chloride is an anesthetic. Inhaling the vapor may cause mental confusion, light-headedness, nausea, vomiting, and headache. Continued exposure may cause increased light-headedness, staggering, unconsciousness, and death. High vapor concentrations may also cause irritation of the eyes and respiratory tract. Exposure to this chemical may make the symptoms of angina worse. Skin exposure to the liquid may cause irritation. If the liquid is held in contact with the skin, it may cause skin burns. Splashes of the liquid into the eyes may cause irritation.

2. Long-term Exposure: Prolonged or repeated exposure to methylene chloride may cause irritation of the skin.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to methylene chloride.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to methylene chloride at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the employee at increased risk, and to establish a baseline for future health monitoring. Examination of the skin, liver, kidneys, cardiovascular system, and blood should be stressed. Clinical impressions of the autonomic nervous system and pulmonary function should be made, with additional tests conducted where indicated.

—Skin disease: Methylene chloride can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver function test: Methylene chloride causes liver damage in animals and this justifies consideration before exposing persons with impaired liver function. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests.

—Kidney disease: Methylene chloride causes kidney damage in animals and this justifies special considera-

---

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

tion before exposing persons with impaired renal function.

—Cardiovascular disease: Because of reports of excessive carbon monoxide levels following exposure to methylene chloride, persons with cardiac disease may be at increased risk.

—A complete blood count: A complete blood count should be performed, including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit. Carboxyhemoglobin values should also be determined periodically, and any level above 5% should prompt an investigation of the worker and his workplace.

2. *Periodic Medical Examination:* The aforementioned medical examinations should be repeated on an annual basis.

- Summary of toxicology

Methylene chloride vapor is a mild narcotic. Exposure of animals to 15,000 ppm for 7 hours was fatal. Animal experiments have shown that continuous exposure to 1,000 ppm can be lethal in 5 to 7 weeks for dogs and that fatty livers, icterus, pneumonia, and splenic atrophy developed in dogs. Cardiac arrhytmias attributed to sensitization of the myocardium have been observed following exposure to high concentrations of some chlorinated hydrocarbons, but dogs exposed to 10,000 and 20,000 ppm of methylene chloride did not show this phenomenon. In human experiments, inhalation of 500 to 1000 ppm for 1 to 2 hours resulted in lightheadedness; there was sustained elevation of carboxyhemoglobin level. High exposures have resulted in deaths in industrial situations. Lower but unknown concentrations have caused such symptoms as lightheadedness, weakness, nausea, and "drunken behavior," resulting in mistakes and accidental falls. Phosgene poisoning has been reported to occur in several cases where methylene chloride was used in the presence of an open fire. Liquid methylene chloride is irritating to the skin on repeated contact. Splashed in the eye, it is painfully irritating, but is not likely to cause serious injury.

CHEMICAL AND PHYSICAL PROPERTIES

- Physical data

1. Molecular weight: 84.9
2. Boiling point (760 mm Hg): 39.8 C (104 F)
3. Specific gravity (water = 1): 1.3
4. Vapor density (air = 1 at boiling point of methylene chloride): 2.9
5. Melting point: −97 C (−142 F)
6. Vapor pressure at 20 C (68 F): 350 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 1.32
8. Evaporation rate (butyl acetate = 1): 27.5

- Reactivity

1. Conditions contributing to instability: Heat and moisture
2. Incompatibilities: Contact with strong oxidizers, strong caustics, and chemically active metals such as aluminum or magnesium powder, sodium and potassium may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, phosgene, and carbon monoxide) may be released in a fire involving methylene chloride.
4. Special precautions: Liquid methylene chloride will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Flash point: None with normal test method
2. Autoignition temperature: 556 C (1033 F)
3. Flammable limits in air, % by volume: (at elevated temperatures) Lower: 12; Upper: 19
4. Extinguishant: Dry chemical, carbon dioxide, foam

- **Warning properties**

1. Odor Threshold: Different authors have reported varying odor thresholds for methylene chloride. Summer and May both report 150 ppm; Kirk-Othmer and Sax both report 25 to 50 ppm; Spector reports 320 ppm. Patty, however, states that since one can become adapted to the odor, it cannot be considered an adequate warning property.

2. Eye Irritation Level: Grant reports that methylene chloride "presents no particular hazard to the eyes." Kirk-Othmer, however, reports that "methylene chloride vapor is seriously damaging to the eyes." Sax agrees with Kirk-Othmer's statement.

The *Documentation of TLV's* states that irritation of the eyes has been observed in workers who had been exposed to concentrations up to 5000 ppm, but that neurasthenic disorders were found in 50% and digestive disturbances in 30% of the persons exposed.

3. Other Information: Gleason reports that methylene chloride may be "irritating to the respiratory tract and may produce pulmonary edema" but gives no quantitative information. The *Documentation of TLV's* reports that in one investigation, irritation of the respiratory passages was observed in workers who had been exposed to concentrations up to 5000 ppm.

4. Evaluation of Warning Properties: Since no detailed information is available relating the irritant effects of methylene chloride to air concentrations and since adaptation to the odor occurs, methylene chloride is treated as a material with poor warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of methylene chloride. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Peak Above Ceiling Evaluation**

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of methylene chloride. Each measurement should consist of a 30-minute sample or a series of consecutive samples totalling 30 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure methylene chloride may be used. An analytical method for methylene chloride is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid methylene chloride.
- Non-impervious clothing which becomes wet with liquid methylene chloride should be removed promptly and not reworn until the methylene chloride is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid methylene chloride may contact the eyes.

SANITATION

- Skin that becomes wet with liquid methylene chloride should be promptly washed or showered with soap or mild detergent and water to remove any methylene chloride.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to methylene chloride may occur and control methods which may be effective in each case:

Operation	Controls
Use as a solvent in paint and varnish removers; manufacture of aerosols; cold cleaning and ultrasonic cleaning; and as an extraction solvent for foods and furniture processing	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a cooling solvent in manufacture of cellulose acetate; in organic synthesis; and in plastics processing	Process enclosure; local exhaust ventilation
Use as a solvent in vapor degreasing of thermal switches and thermometers	Process enclosure; local exhaust ventilation
Use as a secondary refrigerant in air conditioning and scientific testing	General dilution ventilation; local exhaust ventilation; personal protective equipment

Operation	Controls
Use as an extraction solvent for edible fats, coca, butter, beer flavoring in hops, decaffeinated coffee, oleoresin manufacture, oils, waxes, perfumes, flavorings, and drugs	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a solvent for paints, lacquers, varnishes, enamels, adhesives, rubber cements, manufacture of printed circuit boards, as a carrier for pharmaceutical tablet coatings, shrink-fitting of synthetic rubber covers, and dyeing of synthetic fibers	General dilution ventilation; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If methylene chloride gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If methylene chloride gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water if the methylene chloride has not already evaporated. If methylene chloride soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

- **Breathing**

If a person breathes in large amounts of methylene chloride, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Swallowing**

When methylene chloride has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND LEAK PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If methylene chloride is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. Collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Methylene Chloride," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "Dichloromethane," *Hygienic Guide Series*, Detroit, Michigan, 1965.
- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- Hughes, J. P.: "Hazardous Exposure to Some So-Called Safe Solvents," *Journal of the American Medical Association*, 156:234-237, Sept. 18, 1954.
- *Hygienic Information Guide No. 98 – Methylene Chloride*, Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Occupational Health, 1963.
- Kirk, R., and Othmer, D.: *Encyclopedia of Chemical Technology* (2nd ed.), Interscience, New York, 1968.
- Manufacturing Chemists Association, Inc.: *Chemical Safety Data Sheet SD-86, Methylene Chloride*, Washington, D.C., 1962. D.C., 1962.
- May, J.: "Solvent Odor Thresholds for the Evaluation of Solvent Odors in the Atmosphere," *Staub-Reinhalt*, 26:9, 385-389, 1966.
- National Fire Protection Association: *Fire Protection Handbook* (13th ed.), National Fire Protection Association, Boston, 1969.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to Methylene Chloride*, HEW Publication No. (NIOSH) 76-138, GPO No. 017-033-00194-4, U.S. Government Printing Office, Washing-

ton, D.C., 1976.

- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
- Reinhardt, C. F., et al.: "Epinephrine-Induced Cardiac Arrythmia Potential of Some Common Industrial Solvents," *Journal of Occupational Medicine*, 15:953-955, 1973.
- Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.
- Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.
- Stecher, P. G. (ed.): *The Merck Index* (8th ed.), Merck Co., Inc., Rahway, New Jersey, 1968.
- Stewart, R. D., and Dodd, H. C.: "Absorption of Carbon Tetrachloride, Trichloroethylene, Tetrachloroethylene, Methylene Chloride, and 1,1,1-Trichloroethane through the Human Skin," *Industrial Hygiene Journal*, Sept. - Oct., 1964, p. 439.
- Stewart, R. D., et al.: "Experimental Human Exposure to Methylene Chloride," *Archives of Environmental Health*, 25:342-348, 1972.
- Summer, W.: *Odor Pollution of Air: Causes and Control*, L. Hill, London, 1975.
- Thienes, C. H., and Haley, T. J.: *Clinical Toxicology* (5th ed.), Lea and Febiger, Philadelphia, 1972.

RESPIRATORY PROTECTION FOR METHYLENE CHLORIDE

Condition	**Minimum Respiratory Protection* Required Above 500 ppm**
Vapor Concentration	
5000 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 5000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Naphthalene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $C_{10}H_8$
- Synonyms: White tar; naphthalin
- Appearance and odor: Colorless to brown solid with the odor of mothballs.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for naphthalene is 10 parts of naphthalene per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 50 milligrams of naphthalene per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Naphthalene can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

1. Short-term Exposure: Inhalation or ingestion of naphthalene may cause abdominal cramps, nausea, vomiting, diarrhea, headache, tiredness, confusion, painful urination, and bloody or dark urine. Swallowing large amounts may cause convulsions or coma. Inhalation, ingestion, and possibly skin absorption of naphthalene may cause destruction of red blood cells with anemia, fever, yellow jaundice, bloody urine, kidney and liver damage. Naphthalene, on contact with the eyes, has produced irritation. Naphthalene, on contact with the skin, has produced skin irritation.

2. Long-term Exposure: Repeated skin exposure to naphthalene may cause an allergic rash. Repeated exposure may cause cataracts.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to naphthalene.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to naphthalene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a deficiency of glucose-6-phosphate dehydrogenase in erythrocytes may be at increased risk from exposure. Examination of the eyes, blood, liver and kidneys should be stressed. The skin should be examined for evidence of chronic disorders.

—A complete blood count: Naphthalene has been shown to cause red blood cell hemolysis. A complete blood count should be performed, including a red cell count, a white cell count, and a differential count of a stained smear, as well as hemoglobin and hematocrit.

—Urinalysis: Since kidney damage may also occur from exposure to naphthalene, a urinalysis should be performed, including at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

Naphthalene vapor causes hemolysis and eye irritation; it may cause cataracts. Severe intoxication from ingestion of the solid results in characteristic manifestations of marked intravascular hemolysis and its consequences, including potentially fatal hyperkalemia. Initial symptoms include eye irritation, headache, confu-

---

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

sion, excitement, malaise, profuse sweating, nausea, vomiting, abdominal pain, and irritation of the bladder; there may be progression to jaundice, hematuria, hemoglobinuria, renal tubular blockage, and acute renal shutdown. Hematologic features include red cell fragmentation, icterus, severe anemia with nucleated red cells, leukocytosis, and dramatic decreases in hemoglobin, hematocrit, and red cell count; sometimes there is formation of Heinz bodies and methemoglobin. Individuals with a deficiency of glucose-6-phosphate dehydrogenase in erythrocytes may be more susceptible to hemolysis by naphthalene. Cataracts and ocular irritation have been produced experimentally in animals and have been described in humans; of 21 workers exposed to high concentrations of fume or vapor for 5 years, 8 had peripheral lens opacities; in other studies no abnormalities of the eyes have been detected in workers exposed to naphthalene for several years. The vapor causes eye irritation at 15 ppm; eye contact with the solid may result in conjunctivitis, superficial injury to the cornea, chorioretinitis, scotoma, and diminished visual acuity. Naphthalene on the skin may cause hypersensitivity dermatitis; chronic dermatitis is rare.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 128.2
2. Boiling point (760 mm Hg): 218 C (424 F)
3. Specific gravity (water = 1): 1.14
4. Vapor density (air = 1 at boiling point of naphthalene): 4.4
5. Melting point: 74 – 80 C (165 – 176 F)
6. Vapor pressure at 20 C (68 F): 0.05 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 0.003
8. Evaporation rate (butyl acetate = 1): Much less than 1

- **Reactivity**

1. Conditions contributing to instability: None.
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as dense acrid smoke and carbon monoxide) may be released in a fire involving naphthalene.
4. Special precautions: Melted naphthalene will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Flash point: 79 C (174 F) (closed cup)
2. Autoignition temperature: 526 C (979 F)
3. Flammable limits in air, % by volume: Lower: 0.9; Upper: 5.9
4. Extinguishant: Carbon dioxide, dry chemical, foam

- **Warning properties**

1. Odor Threshold: The AIHA *Hygienic Guide* reports that the odor threshold of naphthalene is "at least as low as 0.3 ppm."
2. Eye Irritation Level: The *Hygienic Guide* states that "naphthalene vapor is reported to cause eye irritation at 15 ppm or above in air."
3. Evaluation of Warning Properties: Through its odor and irritant effects, naphthalene can be detected at or below the permissible exposure limit. Naphthalene, therefore, is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure naphthalene may be used. An analytical method for naphthalene is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 4, 1978, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00317-3).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with naphthalene or liquids containing naphthalene.
- If employees' clothing may have become contaminated with solid naphthalene, employees should change into uncontaminated clothing before leaving the work premises.
- Clothing contaminated with naphthalene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of naphthalene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the naphthalene, the person performing the operation should be informed of naphthalene's hazardous properties.
- Non-impervious clothing which becomes contaminated with naphthalene should be removed promptly and not reworn until the naphthalene is removed from the clothing.
- Employees should be provided with and required to use dust- and splash-proof safety goggles where solid naphthalene or liquids containing naphthalene may contact the eyes.

SANITATION

- Skin that becomes contaminated with naphthalene should be promptly washed or showered with soap or mild detergent and water to remove any naphthalene.
- Eating and smoking should not be permitted in areas where solid naphthalene is handled, processed, or stored.
- Employees who handle naphthalene or liquids containing naphthalene should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to naphthalene may occur and control methods which may be effective in each case:

Operation	Controls
Formulation of insecticide and moth repellant as flakes, powder, balls, or cakes	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as a fumigant for moth repellant and insecticide	General dilution ventilation; personal protective equipment
Use in manufacture of chemical intermediates for production of pharmaceuticals, resins, dyes, plasticizers, solvents, coatings, insecticides, pigments, rubber chemicals, tanning agents, surfactants, waxes, cable coatings, textile spinning lubricants, rodenticides, and in storage batteries	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Manufacture of naphthalene	Local exhaust ventilation; process enclosure; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If naphthalene or liquids containing naphthalene get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If molten naphthalene gets on the skin, immediately flush the skin with large amounts of water. Get medical attention immediately. If naphthalene or liquids containing naphthalene get on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If naphthalene or liquids containing naphthalene penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

- **Breathing**

If a person breathes in large amounts of naphthalene, move the exposed person to fresh air at once.

- **Swallowing**

When naphthalene has been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed.
- If naphthalene is spilled, the following steps should be taken:

1. Ventilate area of spill.
2. For small quantities, sweep onto paper or other suitable material, place in an appropriate container and burn in a safe place (such as a fume hood). Large quantities may be reclaimed; however, if this is not practical, dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber.

- Waste disposal methods:

Naphthalene may be disposed of:

1. By making packages of naphthalene in paper or other flammable material and burning in a suitable combustion chamber.
2. By dissolving naphthalene in a flammable solvent (such as alcohol) and atomizing in a suitable combustion chamber.

ADDITIONAL INFORMATION

To find additional information on naphthalene, look up naphthalene in the following documents:

- Medical Surveillance for Chemical Hazards
- Respiratory Protection for Chemical Hazards
- Personal Protection and Sanitation for Chemical Hazards

These documents are available through the NIOSH Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Naphthalene," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "Naphthalene," *Hygienic Guide Series,* Detroit, Michigan, 1967.
- American Petroleum Institute: "Naphthalene," *API Toxicological Reviews,* New York, 1959.
- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List,* 1974 Edition, HEW Publication No. 74-134, 1974.
- Deichmann, W. B., and Gerarde, H. W.: *Toxicology of Drugs and Chemicals,* Academic Press, New York, 1969.
- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products*(3rd ed.), Williams and Wilkins, Baltimore, 1969.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- International Labour Office: *Encyclopedia of Occupational Health and Safety,* McGraw-Hill, New York, 1971.
- Manufacturing Chemists Association, Inc.: *Chemical Safety Data Sheet SD-58, Naphthalene,* Washington, D.C.
- Patty, F. A. (ed.): *Toxicology,* Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
- Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology,* Saunders, Philadelphia, 1956-1959.
- Stecher, P. G. (ed.): *The Merck Index* (8th ed.), Merck Co., Inc., Rahway, New Jersey, 1968.
- Stolman, A. (ed.): *Progress in Chemical Toxicology,* Academic Press, New York, 1965-1969.
- Union Carbide Corporation Industrial Medicine and Toxicology Department: *Toxicology Studies – Naphthalene,* New York, 1968.
- Zinkham, W. H., and Childs, B.: "A Defect of Glutathione Metabolism in Erythrocytes from Patients with a Naphthalene-Induced Hemolytic Anemia," *Pediatrics,* 22:461-471, 1958.

Occupational Health Guideline for Phenol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: C_6H_5OH
- Synonyms: Carbolic acid; monohydroxybenzene
- Appearance and odor: Colorless to pink solid or thick liquid with a characteristic, sweet, tarry odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for phenol is 5 parts of phenol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 19 milligrams of phenol per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 20 mg/m^3 averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 60 mg/m^3 averaged over a 15-minute period. The NIOSH Criteria Document for Phenol should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Phenol can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

1. Short-term Exposure: Phenol has a marked corrosive effect on any tissue. When it comes in contact with the eyes, it may cause severe damage and blindness. On contact with the skin, it does not cause pain but causes a whitening of the exposed area. If the chemical is not removed promptly, it may cause a severe burn or systemic poisoning. Systemic effects may occur from any route of exposure, especially after skin contact.

2. Long-term Exposure: Repeated or prolonged exposure to phenol may cause chronic phenol poisoning. The symptoms of chronic poisoning include vomiting, difficulty in swallowing, diarrhea, lack of appetite, headache, fainting, dizziness, dark urine, mental disturbances, and possibly a skin rash. Liver damage and discoloration of the skin may occur.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to phenol.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to phenol at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of convulsive disorders or abnormalities of the skin, respiratory tract, liver, or kidneys would be expected to be at increased risk from exposure. Examination of the liver, kidneys, and respiratory tract should be stressed. The skin should be examined for evidence of chronic disorders.

—Urinalysis: Darkening of the urine has occurred in persons exposed to phenol after accidental ingestion or skin contact. A urinalysis should be performed, including at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. Urinary phenol is useful if good individual background levels are available.

—Liver function tests: Since liver damage has been observed in humans exposed to phenol, a profile of liver function should be performed by using a medically acceptable array of biochemical tests.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

2. *Periodic Medical Examination:* The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

Phenol in the vapor form or in solution is an irritant to the eyes, mucous membranes, and skin; systemic absorption causes central nervous system effects as well as liver and kidney damage. Sudden collapse is characteristic of gross overexposure. In animals, prolonged inhalation of the vapor at 30 to 60 ppm induced respiratory difficulty, lung damage, and paralysis. Systemic absorption by animals caused muscle twitching and severe convulsions. There are no reports of human fatalities from inhalation of the vapor, although one case of severe poisoning has been reported. Ingestion of lethal amounts (as little as 1 g) cause severe burns of the mouth and throat, marked abdominal pain, cyanosis, muscular weakness, collapse, coma, and death; tremors, convulsions, or muscle twitching were occasionally observed but were not severe. A laboratory technician repeatedly exposed to unknown vapor concentrations and liquid spilled on the skin developed anorexia, weight loss, weakness, muscle aches and pain, and dark urine; during several months of nonexposure there was gradual improvement in his condition, but after brief reexposure he suffered an immediate worsening of symptoms with prompt darkening of the urine and tender enlargement of the liver. Brief intermittent industrial exposures to vapor concentrations of 48 ppm of phenol (accompanied by 8 ppm of formaldehyde) caused marked irritation of eyes, nose, and throat. Concentrated phenol solutions are severely irritating to the human eye and cause conjunctival swelling; the cornea becomes white and hypesthetic; loss of vision has occurred in some cases. Solutions of phenol have a marked corrosive action on any tissue on contact; on skin, there is local anesthesia and a white discoloration, and the area may subsequently become gangrenous; severe dermatitis will result from contact with dilute solutions, and prolonged exposure may result in ochronosis. In workers making phenol-formaldehyde plastic, the urinary level of total phenol, free plus conjugated, was proportional to the air concentration of phenol up to 12.5 mg/m^3 of workroom air. Mice were treated twice weekly for 72 weeks by application of 1 drop of a 10% solution of phenol in benzene to the shaved dorsal skin; after 52 weeks of treatment there were papillomas in 5 of 14 mice, and 1 fibrosarcoma appeared at 58 weeks.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 94.11
2. Boiling point (760 mm Hg): 182 C (359 F)
3. Specific gravity (water = 1): 107 (solid); 1.05 (liquid)
4. Vapor density (air = 1 at boiling point of phenol): 3.24
5. Melting point: 41 C (106 F)
6. Vapor pressure at 20 C (68 F): 0.36 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 8.4
8. Evaporation rate (butyl acetate = 1): Less than 0.01

- **Reactivity**

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizers (especially calcium hypochlorite) may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving phenol.
4. Special precautions: Liquid phenol will attack some forms of plastics, rubber, and coatings. Hot liquid phenol will attack aluminum, magnesium, lead, and zinc metals.

- **Flammability**

1. Flash point: 79 C (174 F) (closed cup)
2. Autoignition temperature: 715 C (1319 F)
3. Flammable limits in air, % by volume: Lower: 1.7; Upper: 8.6
4. Extinguishant: Alcohol foam, carbon dioxide, dry chemical

- **Warning properties**

1. Odor Threshold: Summer reports that the odor threshold of phenol is 3 ppm; the Manufacturing Chemists Association reports 0.3 ppm; Thienes and Haley report 5 ppm.
2. Irritation Levels: The *Documentation of TLV's* reports that intermittent exposures to 48 ppm phenol have been observed to produce eye, nose, and throat irritation. Formaldehyde was also present in this atmosphere at a concentration of 8 ppm. The Respirator Review Committee considers the source of the eye irritation to be the 8 ppm formaldehyde rather than the phenol.
3. Evaluation of Warning Properties: Since the odor threshold of phenol is at or below the permissible exposure limit, phenol is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of phenol. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- Method

Sampling and analyses may be performed by collection of phenol in a bubbler containing sodium hydroxide, followed by treatment with sulfuric acid, and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure phenol may be used. An analytical method for phenol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 6, 1980, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00369-6).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with solid or liquid phenol or liquids containing phenol.
- If employees' clothing has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol, employees should change into uncontaminated clothing before leaving the work premises.
- Clothing which has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of phenol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the phenol, the person performing the operation should be informed of phenol's hazardous properties.
- Where there is any possibility of exposure of an employee's body to solid or liquid phenol or liquids containing phenol, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.
- Non-impervious clothing which becomes contaminated with phenol should be removed immediately and not reworn until the phenol is removed from the clothing.
- Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of solid or liquid phenol or liquids containing phenol contacting the eyes.
- Where there is any possibility that employees' eyes may be exposed to solid or liquid phenol or liquids containing phenol, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes contaminated with phenol should be immediately washed or showered with soap or mild detergent and water to remove any phenol.
- Any clothing which becomes wet with liquid phenol or liquids containing phenol should be removed immediately and not reworn until the phenol is removed from the clothing.
- Eating and smoking should not be permitted in areas where solid or liquid phenol or liquids containing phenol are handled, processed, or stored.
- Employees who handle solid or liquid phenol or liquids containing phenol should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to phenol may occur and control methods which may be effective in each case:

Operation	Controls
Application and curing of bonding resin in plywood manufacture; application and curing of molding resins in manufacture of molded articles, such as	Process enclosure, local exhaust ventilation; personal protective equipment

electrical appliances, automotive parts, foundry sand molds, and utensil handles; manufacture of friction materials, bonded abrasives, coated abrasives, wood particle board, and insulation materials	
Use in industrial coatings in drum and can linings, milk and beer-processing equipment, water tanks and air-conditioning equipment, decorative laminates, and textile coatings	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of thermosetting phenolic resins, epoxy, polycarbonate, phenoxy, and polysulfone; synthesis of aprolactam for use in nylon 6 fibers, plastics, and films	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of agricultural chemicals and intermediates; synthesis of pharmaceuticals, rubber and plastic plasticizers, antioxidants, curing agents, and intermediates	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of stabilizers and preservatives for dyes, perfumes, and fungicides	Process enclosure; local exhaust ventilation; personal protective equipment
Use during solvent refining of lubrication oil and wax; use in synthesis of additives for gasoline and lubricating fluids and intermediates	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of intermediates in polyester production; production of corrosion-resistant polyester and polyester polyols; use in synthesis of dye intermediates	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of surface-active agents and detergent intermediates; in synthesis of explosives	Process enclosure; local exhaust ventilation; personal protective equipment
Use in manufacture of disinfectant agents and products for industrial and household use	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of synthetic cresols and xylenols	Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If solid or liquid phenol or liquids containing phenol get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If solid or liquid phenol or liquids containing phenol get on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If solid or liquid phenol or liquids containing phenol penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Get medical attention immediately.

- **Breathing**

If a person breathes in large amounts of phenol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Swallowing**

When solid or liquid phenol or liquids containing phenol have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

- Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If phenol is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill.
2. If in the solid form, for small quantities, sweep onto paper or other suitable material, place in an appropriate container and burn in a safe place (such as a fume hood). Large quantities may be reclaimed; however, if this is not practical, dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber.
3. If in the liquid form, for small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber.

- Waste disposal methods:

Phenol may be disposed of:

1. If in the solid form, by making packages of phenol in paper or other flammable material and burning in a suitable combustion chamber, or by dissolving phenol in a flammable solvent (such as alcohol) and atomizing in a suitable combustion chamber.
2. If in the liquid form, by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill, or by atomizing the liquid in a suitable combustion chamber.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Phenol," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "Phenol," *Hygienic Guide Series*, Detroit, Michigan, 1957.
- Baskin, A. D. (ed.): *Handling Guide for Potentially Hazardous Commodities*, Railway Systems and Management Association, Chicago, 1972.
- Boutwell, R. K., and Bosch, D. K.: "The Tumor-promoting Action of Phenol and Related Compounds for Mouse Skin," *Cancer Research*, 19:413-424, 1959.
- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.
- Community Air Quality Guides: "Phenol and Cresol," *American Industrial Hygiene Association Journal*, 30:425-428, 1969.
- Deichmann, W. B., and Witherup, S.: "Phenol Studies VI: The Acute and Comparative Toxicity of Phenol and o-, m-, and p-Cresols for Experimental Animals," *Journal of Pharmacolology and Experimental Therapy*, 80, 233, 1944.
- Fairhall, L. T.: *Industrial Toxicology* (2nd ed.), Williams and Wilkins, Baltimore, 1957.
- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- *Hygienic Information Guide No. 40 – Phenol*, Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Occupational Health, 1968.
- Jacobs, M.: *The Analytical Chemistry of Industrial Poisons, Hazards, and Solvents*, Interscience, New York, 1956.
- Manufacturing Chemists Association, Inc.: *Chemical Safety Data Sheet SD-4, Phenol,* Washington, D.C., 1964.
- Merliss, R. R.: "Phenol Marasmus," *Journal of Occupational Medicine*, 14:55-56, 1972.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to Phenol,* HEW Publication No. (NIOSH) 76-196, GPO No. 017-033-00184-7, U.S. Government Printing Office, Washington, D.C., 1976
- Ohtsuji, H., and Ikeda, M.: "Quantitative Relationship between Atmospheric Phenol Vapour and Phenol in the Urine of Workers in Bakelite Factories," *British Journal of Industrial Medicine*, 29:70-73, 1972.
- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
- Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968
- Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.
- Summer, W.: *Odor Pollution of Air: Causes and Control*, L. Hill, London, 1975.
- Thienes, C. H., and Haley, T. J.: *Clinical Toxicology* (5th ed.), Lea and Febiger, Philadelphia, 1972.
- Union Carbide Corporation, Industrial Medicine and Toxicology Department: *Toxicology Studies – Phenol*, New York, 1966.

POLYCHLORINATED BIPHENYL

PCB

Common Synonyms

PCB
Chlorinated biphenyl
Aroclor
Halogenated waxes
Polychloropolyphenyls

Oily liquid to solid powder | Light yellow liquid, or white powder | Weak odor

Sinks in water.

Stop discharge if possible. Keep people away.
Avoid contact with liquid and solid.
Call fire department.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire	Combustible. Extinguish with water, foam, dry chemical, or carbon dioxide.
Exposure	CALL FOR MEDICAL AID. LIQUID OR SOLID Irritating to skin and eyes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water.
Water Pollution	HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Issue warning-water contaminant
Should be removed
Chemical and physical treatment

2. LABEL

2.1 **Category:** None
2.2 **Class:** Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Not listed
3.2 **Formula:** $(C_{12}H_{10-x})Cl_x$
3.3 **IMO/UN Designation:** Not listed
3.4 **DOT ID No.:** 2315
3.5 **CAS Registry No.:** 1336-36-3

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid or solid
4.2 **Color:** Pale yellow (liquid); colorless (solid)
4.3 **Odor:** Practically odorless

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Gloves and protective garments.
5.2 **Symptoms Following Exposure:** Acne from skin contact.
5.3 **Treatment of Exposure:** SKIN: wash with soap and water.
5.4 **Threshold Limit Value:** 0.5 to 1.0 mg/m³
5.5 **Short Term Inhalation Limits:** Data not available
5.6 **Toxicity by Ingestion:** Grade 2; oral rat LD_{50} = 3980 mg/kg
5.7 **Late Toxicity:** Causes chromosomal abnormalities in rats, birth defects in birds
5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause severe irritation of eyes and throat and cause eye and lung injury. They cannot be tolerated even at low concentrations.
5.9 **Liquid or Solid Irritant Characteristics:** Contact with skin may cause irritation.
5.10 **Odor Threshold:** Data not available
5.11 **IDLH Value:** 5 to 10 mg/m³

6. FIRE HAZARDS

6.1 **Flash Point:** >286°F
6.2 **Flammable Limits in Air:** Data not available
6.3 **Fire Extinguishing Agents:** Water, foam, dry chemical, or carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Irritating gases are generated in fires.
6.6 **Behavior in Fire:** Not pertinent
6.7 **Ignition Temperature:** Data not available
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** Data not available
6.10 **Adiabatic Flame Temperature:** Data not available
6.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** Data not available

8. WATER POLLUTION

8.1 **Aquatic Toxicity:**
0.278 ppm/96 hr/bluegill/TL_m/fresh water
0.005 ppm/336-1080 hr/pinfish/TL_m/salt water
8.2 **Waterfowl Toxicity:** LD_{50} 2000 ppm (mallard duck)
8.3 **Biological Oxygen Demand (BOD):** Very low
8.4 **Food Chain Concentration Potential:** High

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** 11 grades (some liquid, some solids) which differ primarily in their chlorine content (20%-68% by weight)
9.2 **Storage Temperature:** Ambient
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Open

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

11

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** ORM-E
11.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed
11.3 **NFPA Hazard Classification:** Not listed

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Solid
12.2 **Molecular Weight:** Not pertinent
12.3 **Boiling Point at 1 atm:** Very high
12.4 **Freezing Point:** Not pertinent
12.5 **Critical Temperature:** Not pertinent
12.6 **Critical Pressure:** Not pertinent
12.7 **Specific Gravity:** 1.3—1.8 at 20°C (liquid)
12.8 **Liquid Surface Tension:** Not pertinent
12.9 **Liquid Water Interfacial Tension:** Not pertinent
12.10 **Vapor (Gas) Specific Gravity:** Not pertinent
12.11 **Ratio of Specific Heats of Vapor (Gas):** Not pertinent
12.12 **Latent Heat of Vaporization:** Not pertinent
12.13 **Heat of Combustion:** Not pertinent
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** Data not available
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** Data not available

NOTES

Occupational Health Guideline for Tetraethyl Lead

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $Pb(C_2H_5)_4$
- Synonyms: TEL; lead tetraethyl; motor fuel anti-knock compound
- Appearance and odor: Colorless liquid (or dyed red, orange, or blue) with a slight musty odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for tetraethyl lead is 0.075 milligrams of tetraethyl lead per cubic meter of air (mg/m³) averaged over an eight-hour work shift. The American Conference of Governmental Industrial Hygienists has recommended that the permissible exposure limit be changed to 0.1 mg/m³. The American Conference of Governmental Industrial Hygienists has recommended for tetraethyl lead a Threshold Limit Value of 0.1 mg/m³ with a skin notation.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Tetraethyl lead can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It may readily enter the body through the skin.

- **Effects of overexposure**

The absorption by humans of a sufficient quantity of tetraethyl lead either briefly at a high rate or for prolonged periods at a lower rate may cause intoxication. The onset of symptoms may be delayed for up to eight days after termination of exposure. The milder toxic effects are difficulty in sleeping, tiredness, wild dreams, anxiety, trembling, spasms, slow heart beat, low body temperature, paleness, nausea and loss of appetite. More severe intoxication causes episodes of disorientation, hallucinations, grimacing, and intense activity which requires that the person be restrained. These episodes may convert into manic or violent convulsive seizures which may end in unconsciousness or death. Tetraethyl lead may cause irritation of the eyes. Fetal damage may occur from exposure of the mother to tetraethyl lead, by analogy to methyl mercury.

- **Reporting signs and symptoms**

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to tetraethyl lead.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to tetraethyl lead at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of mental disorders or hypotension would be expected to be at increased risk from exposure. Examination of the central nervous system and the cardiovascular system should be stressed.

—Urinalysis: Normal kidney function is considered necessary for biologic monitoring. A urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. The concentration of lead should be determined. Urine specimens with a specific gravity less than 1.020 should be discarded and another sampled obtained.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, except that the determination of lead in the urine should be repeated quarterly.

- **Summary of toxicology**

Tetraethyl lead vapor affects the nervous system and

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service   Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

causes mental aberrations including psychosis, mania, and convulsions. Of 41 female Swiss mice which survived for 36 weeks after a single subcutaneous injection of 0.6 mg, 5 developed malignant lymphomas during the next 15 weeks; the significance of these data cannot be evaluated, because this tumor occurs spontaneously with a variable incidence in the mouse strain used. The absorption by humans of a sufficient quantity of tetraethyl lead, either briefly at a high rate (100 mg/m^3 for 1 hour) or for prolonged periods at a lower rate, causes acute intoxication; chronic intoxication has not been observed. The onset of symptoms may be delayed for up to 8 days after termination of exposure. The milder manifestations of intoxication are insomnia, lassitude, lurid dreams, dream-like waking states of anxiety, tremor, hyperreflexia, spasmodic muscular contractions, bradycardia, hypotension, hypothermia, pallor, nausea, and anorexia. More severe intoxication causes recurrent or nearly continuous episodes of disorientation, hallucinations, facial contortions, and intense hyperactivity which requires that the individual be restrained. Such episodes may convert abruptly into manic or violent convulsive seizures which may terminate in coma and death. During intoxication there is a striking elevation of the rate of excretion of lead in the urine but only a negligible or slight elevation of the concentration of lead in the blood. In severe intoxication, the urine lead is rarely less than 350 ug/l of urine, while the blood lead is rarely more than 50 ug/100 g of blood. There is also a total absence of morphological or chemical abnormalities in the erythrocytes, in sharp contrast to intoxication caused by inorganic lead. In a mortality study of 592 workers, the mean exposure time was 17.9 years, and urinary lead levels during this period did not exceed 180 ug/l; the incidence of death in this group and in a control group of employees was less than that expected in the general population, and there were no peculiarities in the specific causes of death in either group. In a similar study of a different cohort of these exposed workers, there were no significant health differences when compared with a control group. Although tetraethyl lead may be irritating to the eyes, this effect is considered insignificant when compared with the effects on the central nervous system.

CHEMICAL AND PHYSICAL PROPERTIES

- Physical data

1. Molecular weight: 323.4

2. Boiling point (760 mm Hg): Decomposes above 100 C (212 F)

3. Specific gravity (water = 1): 1.65

4. Vapor density (air = 1 at boiling point of tetraethyl lead): 8.6

5. Melting point: −138 to −130 C (−216 to −202 F)

6. Vapor pressure at 20 C (68 F): 0.2 mm Hg

7. Solubility in water, g/100 g water at 20 C (68 F): insoluble

8. Evaporation rate (butyl acetate = 1): Data not available

- **Reactivity**

1. Conditions contributing to instability: Temperatures above 100 C (212 F) cause decomposition and development of pressure that may cause containers to burst.

2. Incompatibilities: Contact with strong oxidizers, such as sulfuryl chloride or potassium permanganate, may cause fires and explosions.

3. Hazardous decomposition products: Toxic airborne substances (such as lead fumes and carbon monoxide) may be released in a fire involving tetraethyl lead.

4. Special precautions: Tetraethyl lead will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Flash point: 93 C (200 F) (closed cup)

2. Autoignition temperature: Data not available

3. Flammable limits in air, % by volume: Data not available

4. Extinguishant: Dry chemical, foam, carbon dioxide

- **Warning properties**

1. Odor Threshold: No quantitative information is available concerning the odor threshold of tetraethyl lead. The AIHA *Hygienic Guide* states that this substance "has a characteristic sweetish odor, but the intensity of the odor is not adequate to warn of hazardous concentrations."

2. Eye Irritation Level: Grant states that "concerning local effects on the eye from direct contact, there was recorded by Leake in 1926 a strange account of a contamination of the eyes from a splash of gasoline containing tetraethyl lead, after which the patient was said to have been unable to see for three-fourths of an hour. In the course of two months the patient was reported improved and was found to have no corneal or ophthalmoscopic abnormality, but was thought to have slight mydriasis, photophobia, and contraction of the visual field. Very likely the initial difficulty in seeing was due to smarting sensation in the eyes and blepharospasm. The evidence of later eye abnormality in this case seems quite indefinite and questionable.

"I have tested high-test gasoline containing tetraethyl lead by dropping on rabbit eyes, and have found it to cause immediate pain and blepharospasm lasting several minutes. When the application was repeated ten times in the course of five minutes under local anesthesia, it produced conjunctival hyperemia and moderate flocculent discharge, but no damage to cornea or conjunctiva."

3. Evaluation of Warning Properties: Since there is no quantitative information relating warning properties to air concentrations of tetraethyl lead, this substance is treated as a material with poor warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- Method

An analytical method for tetraethyl lead is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 4, 1978, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00317-3).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with undiluted liquid tetraethyl lead or solutions containing more than 1.06 milliliters per liter (4 milliliters per gallon).
- Clothing contaminated with undiluted liquid tetraethyl lead or solutions containing more than 1.06 milliliters per liter (4 milliliters per gallon) should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of tetraethyl lead from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the tetraethyl lead, the person performing the operation should be informed of tetraethyl lead's hazardous properties.
- If employees' clothing has had any possibility of being contaminated with undiluted liquid tetraethyl lead or solutions containing more than 1.06 milliliters per liter (4 milliliters per gallon), employees should change into uncontaminated clothing before leaving the work premises.
- Non-impervious clothing which becomes contaminated with undiluted liquid tetraethyl lead or solutions containing more than 1.06 milliliters per liter (4 milliliters per gallon) should be removed immediately and not reworn until the tetraethyl lead is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid tetraethyl lead may contact the eyes.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to tetraethyl lead may occur and control methods which may be effective in each case:

Operation	Controls
Liberation during manufacture in preparation of antiknock agents for fuels	Process enclsoure; local exhaust ventilation; personal protective equipment
Liberation during formulation at petroleum refinery for use as an antiknock agent	Local exhaust ventilation; total enclosure; personal protective devices

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If liquid tetraethyl lead or strong concentrations of tetraethyl lead vapors get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If liquid tetraethyl lead or strong concentrations of tetraethyl lead vapors get on the skin, immediately rinse the contaminated skin with kerosene or similar petroleum products, if readily available, then wash the skin using soap or mild detergent and water. If liquid tetraethyl lead or strong concentrations of tetraethyl lead vapors penetrate through the clothing, remove the clothing immediately and first rinse the skin with kerosene or similar petroleum products, if readily available, then wash the skin using soap or mild detergent and water. Get medical attention immediately.

- **Breathing**

If a person breathes in large amounts of tetraethyl lead, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- Swallowing

When tetraethyl lead has been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

- Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If tetraethyl lead is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

- Waste disposal methods:

Tetraethyl lead may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill
2. By atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Tetraethyl Lead," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "Tetraethyl Lead," *Hygienic Guide Series*, Detroit, Michigan, 1963.
- Baskin, A. D. (ed.): *Handling Guide for Potentially Hazardous Commodities*, Railway Systems and Management Association, Chicago, 1972.
- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.
- Epstein, S. S., and Mantel, N.: "Carcinogenicity of Tetraethyl Lead," *Experientia*, 24:580-581, 1968.
- Fleming, A. J.: "Industrial Hygiene and Medical Control Procedures – Manufacture and Handling of Organic Lead Compounds," *Archives of Environmental Health*, 8:266-270, 1964.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- International Agency for Research on Cancer: *Some Inorganic and Organo-Metallic Compounds, Vol. 2 of IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man*, Lyon, France, 1973.
- International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1974.
- *Registry of Toxic Effects of Chemical Substances*, U.S. Department of Health, Education, and Welfare, Rockville, Maryland, June 1975.
- Robinson, T. R.: "The Health of Long Service Tetraethyl Lead Workers," *Journal of Occupational Medicine*18:31-40, 1976.
- Robinson, T. R.: "Twenty-Year Mortality of Tetraethyl Lead Workers," *Journal of Occupational Medicine*, 16:601-605, 1974.
- Sanders, L. W.: "Tetraethyllead Intoxication," *Archives of Environmental Health*, 8:270-277, 1964.
- Stauden, A. (ex. ed.): *Kirk-Othmer Encyclopedia of Chemical Technology* (2nd ed.), Interscience, New York, 1972.

Occupational Health Guideline for 1,1,2,2-Tetrachloroethane

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $CHCl_2CHCl_2$
- Synonyms: Symmetrical-tetrachloroethane; acetylene tetrachloride; sym-tetrachlorethane
- Appearance and odor: Colorless or pale yellow liquid with a sickly sweet odor, like chloroform.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for 1,1,2,2-tetrachloroethane is 5 parts of 1,1,2,2-tetrachloroethane per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 35 milligrams of 1,1,2,2-tetrachloroethane per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be reduced to 1 ppm (6.87 mg/m^3) averaged over a 10-hour work shift. The NIOSH Criteria Document for 1,1,2,2-Tetrachloroethane should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

1,1,2,2-Tetrachloroethane can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may be absorbed through the skin.

- **Effects of overexposure**

1. Short-term Exposure: Breathing in high concentrations of 1,1,2,2-tetrachloroethane may cause irritation of the eyes and nose, nausea, vomiting, and drowsiness. Liver and kidney damage may occur. If the exposure was severe, within a few hours a deep dusky coloration of the skin may appear, followed by unconsciousness and death. If the exposed worker is removed immediately, he may recover completely but should be placed under observation in case late symptoms appear. If the vapor or liquid of 1,1,2,2-tetrachloroethane gets into the eyes, it may cause watering and burning. It may cause serious eye damage unless immediate medical care is obtained.

2. Long-term Exposure: Prolonged or repeated exposure to 1,1,2,2-tetrachloroethane, either by breathing or by absorbing it through the skin, may cause fatigue, loss of appetite, tremors, weight loss, constipation, heart damage, blood changes, kidney damage, abdominal distress or pain, vomiting, dizziness, tenderness, liver damage with such symptoms as pain over the liver, dark urine, and yellow jaundice. Reproductive abnormalities have been noted in studies of animals following exposure to high levels of 1,1,2,2-tetrachloroethane. Prolonged or repeated skin contact with 1,1,2,2-tetrachloroethane may also cause skin irritation.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to 1,1,2,2-tetrachloroethane.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to 1,1,2,2-tetrachloroethane at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the liver, kidneys, and central nervous system should be stressed.

—Liver function tests: 1,1,2,2-Tetrachloroethane causes liver damage. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

—Urinalysis: Since kidney damage has also been observed from exposure, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.
2. *Periodic Medical Examination:* The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

1,1,2,2-Tetrachloroethane is highly toxic to the liver and is a central nervous system depressant. Rats exposed to 500 ppm for 4 hours survived, but 1,000 ppm was fatal. Reports of industrial experience indicate that cases of mild intoxication have presented symptoms of gastrointestinal irritation (nausea, vomiting, abdominal pain, anorexia) and central nervous system effects (dizziness, headache, irritability, nervousness, insomnia); more severe exposure resulted in liver involvement (enlarged and tender liver, jaundice, bilirubinuria), nephritis (albuminuria and casts); and tremors of hands and eyelids. In cases of severe industrial intoxication, there was hepatic necrosis with jaundice, sometimes progressing to cirrhosis; individuals who died during the acute stage also showed cerebral edema and pulmonary edema with hemorrhage, as well as liver and kidney injury. One study reported that human subjects exposed to 335 ppm for 10 minutes or 186 ppm for 30 minutes noted a disagreeable odor; there were some upper respiratory irritation and central nervous system effects. Among a group of workers in India exposed to 20-65 ppm there was nausea, vomiting, and abdominal pain and a high incidence of tremor of the hands. Prolonged skin exposure may be expected to produce dermatitis due to defatting action. Eye damage has been reported.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 167.8
2. Boiling point (760 mm Hg): 146 C (295 F)
3. Specific gravity (water = 1): 1.6
4. Vapor density (air = 1 at boiling point of 1,1,2,2-tetrachloroethane): 5.8
5. Melting point: −42.5 C (−44.5 F)
6. Vapor pressure at 20 C (68 F): 8 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 0.29
8. Evaporation rate (butyl acetate = 1): 0.65

- **Reactivity**

1. Conditions contributing to instability: Heat; undue exposure to light in the presence of air may form small amounts of phosgene.
2. Incompatibilities: Reacts with chemically active metals or with strong caustics. In the presence of steam, contact with hot iron, aluminum, and zinc may cause formation of toxic vapors.
3. Hazardous decomposition products: Toxic gases and vapors (such as phosgene, hydrogen chloride, chlorinated solvents, and carbon monoxide) may be released when 1,1,2,2-tetrachloroethane decomposes.
4. Special precautions: Liquid 1,1,2,2-tetrachloroethane will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Not combustible

- **Warning properties**

Patty states that the odor of 1,1,2,2-tetrachloroethane is detectable at 5 ppm (3 ppm, according to Lehmann). Since the odor threshold is at (or below) the permissible exposure limit, this compound is treated as a material with good warning properties.

Grant indicates that this compound is not an eye irritant.

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure 1,1,2,2-tetrachloroethane may be used. An analytical method for 1,1,2,2-tetrachloroethane is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).
PB 265 028).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with liquid 1,1,2,2-tetrachloroethane.
- Clothing contaminated with liquid 1,1,2,2-tetrachloroethane should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of 1,1,2,2-tetrachloroethane from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the 1,1,2,2-tetrachloroethane, the person performing the operation should be informed of 1,1,2,2-tetrachloroethane's hazardous properties.
- Where exposure of an employee's body to liquid 1,1,2,2-tetrachloroethane may occur, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.
- Non-impervious clothing which becomes contaminated with liquid 1,1,2,2-tetrachloroethane should be removed immediately and not reworn until the 1,1,2,2-tetrachloroethane is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where there is any possibility of liquid 1,1,2,2-tetrachloroethane contacting the eyes.
- Where there is any possibility that employees' eyes may be exposed to liquid 1,1,2,2-tetrachloroethane, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes contaminated with liquid 1,1,2,2-tetrachloroethane should be immediately washed or showered with soap or mild detergent and water to remove any 1,1,2,2-tetrachloroethane.
- Eating and smoking should not be permitted in areas where liquid 1,1,2,2-tetrachloroethane is handled, processed, or stored.
- Employees who handle liquid 1,1,2,2-tetrachloroethane should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to 1,1,2,2-tetrachloroethane may occur and control methods which may be effective in each case:

Operation	Controls
Use as a chemical intermediate in manufacture of tetrachloroethylene and trichloroethylene; use in cleaning and extraction processes; use in chlorination of phthalic anhydride; use in manufacture of cyanogen chloride, polymers, and tetrachloro-alkylphenol	Local exhaust ventilation; general dilution ventilation
Use as a fumigant in greenhouses	Personal protective equipment
Use in manufacture of lacquers and varnishes, paint and varnish removers	Process enclosure; local exhaust ventilation; personal protective equipment
Liberation during use and preparation of insecticides and weed killers	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in cleaning and degreasing of metals	Process enclosure; local exhaust ventilation; personal protective equipment
Use as a solvent in preparation of adhesives	Local exhaust ventilation
Use during addition to aliphatic alcohols and acetates to improve solvency for nitrocellulose and cellulose acetate as in photographic film	Local exhaust ventilation
Use in application of adhesives	General dilution ventilation; personal protective equipment
Use in refining of waxes and resins	Local exhaust ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If 1,1,2,2-tetrachloroethane gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- Skin Exposure

If 1,1,2,2-tetrachloroethane gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If 1,1,2,2-tetrachloroethane soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

- Breathing

If a person breathes in large amounts of 1,1,2,2-tetrachloroethane, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- Swallowing

When 1,1,2,2-tetrachloroethane has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

- Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If 1,1,2,2-tetrachloroethane is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. Collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material.

- Waste disposal method:

1,1,2,2-Tetrachloroethane may be disposed of by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.

ADDITIONAL INFORMATION

To find additional information on 1,1,2,2-tetrachloroethane, look up 1,1,2,2-tetrachloroethane in the following documents:

- Medical Surveillance for Chemical Hazards
- Respiratory Protection for Chemical Hazards
- Personal Protection and Sanitation for Chemical Hazards
- NIOSH Criteria Document for 1,1,2,2-Tetrachloroethane (December 1976)

These documents are available through the NIOSH Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "1,1,2,2-Tetrachloroethane," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- Browning, E.: *Toxicity and Metabolism of Industrial Solvents*, Elsevier, New York, 1965.
- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products5(3rd ed.), Williams and Wilkins, Baltimore. 1969.*
- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.
Survey," *British Journal of Industrial Medicine*, 20:50-56, 1963.
- Manufacturing Chemists Association, Inc.: *Chemical Safety Data Sheet SD-34, 1,1,2,2-Tetrachloroethane*, Washington, D.C., 1949.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to 1,1,2,2-Tetrachloroethane*, HEW Publication No. (NIOSH) 77-121, GPO No. 017-033-00179-1, U.S. Government Printing Office, Washington, D.C., 1976.
- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
- Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.
- von Oettingen, W. F.: *The Halogenated Aliphatic, Olefinic, Cyclic, Aromatic, and Aliphatic-Aromatic Hydrocarbons Including the Halogenated Insecticides, Their Toxicity and Potential Dangers.* U.S. Public Health Service Publication No. 414, U.S. Government Printing Office, Washington, D.C., 1955.

Occupational Health Guideline for Toluene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $C_6H_5CH_3$
- Synonyms: Toluol; phenylmethane; methylbenzene
- Appearance and odor: Colorless liquid with an aromatic odor, like benzene.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for toluene is 200 parts of toluene per million parts of air (ppm) averaged over an eight-hour work shift, and during any such work shift, 300 ppm toluene may not be exceeded except that a peak of 500 ppm toluene is permitted for 10 minutes during the eight-hour work shift. NIOSH has recommended that the permissible exposure limit be reduced to 100 ppm toluene averaged over an eight-hour work shift with a ceiling level of 200 ppm averaged over a ten-minute period. The NIOSH Criteria Document for Toluene should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Toluene can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

1. Short-term Exposure: Toluene may cause irritation of the eyes, respiratory tract, and skin. It may also cause fatigue, weakness, confusion, headache, dizziness, and drowsiness. Peculiar skin sensation may be produced such as a "pins and needles feeling" or numbness. Very high concentrations may cause unconsciousness and death. The liquid splashed in the eye may cause irritation and temporary damage. Inhalation may also cause difficulty in seeing in bright light. If liquid toluene is splashed in the eyes, it will cause temporary irritation.

2. Long-term Exposure: Repeated or prolonged exposure to liquid toluene may cause drying and cracking of the skin.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to toluene.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to toluene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the central nervous system, liver and kidneys should be stressed. The skin should be examined for evidence of chronic disorders.

—Urinalysis: Since proper kidney function is necessary for biologic monitoring, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. The urine should be analyzed for hippuric acid to obtain a background level.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis. Hippuric acid level in urine may be an indicator of the level of toluene exposure.

- **Summary of toxicology**

Toluene vapor causes narcosis. Controlled exposure of human subjects to 200 ppm for 8 hours produced mild fatigue, weakness, confusion, lacrimation, and paresthesia; at 600 ppm for 8 hours there were also euphoria, headache, dizziness, dilated pupils and nausea; at 800

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

ppm for 8 hours, symptoms were more pronounced, and after-effects included nervousness, muscular fatigue, and insomnia persisting for several days. Severe but reversible liver and kidney injury occurred in a person who was a glue-sniffer for 3 years; the chief component of the inhaled solvent was toluene (80% V/V); other ingredients were not listed. In workers exposed for many years to concentrations in the range of 80 to 300 ppm, there was no clinical or laboratory evidence of altered liver function. Toluene exposure does not result in the hematopoietic effects caused by benzene; the myelotoxic effects previously attributed to toluene are judged by more recent investigations to be the result of concurrent exposure to benzene present as a contaminant in the commercial toluene used. Most of the toluene absorbed from inhalation is metabolized to benzoic acid, conjugated with glycine in the liver to form hippuric acid, and excreted in the urine; the average amount of hippuric acid excreted in the urine by individuals not exposed to toluene is approximately 0.7 to 1.0 g/l of urine. The liquid splashed in the eyes of two workers caused transient corneal damage and conjunctival irritation; complete recovery occurred within 48 hours. Repeated or prolonged skin contact with liquid toluene has a defatting action, causing drying, fissuring, and dermatitis.

CHEMICAL AND PHYSICAL PROPERTIES

- Physical data

1. Molecular weight: 92.1
2. Boiling point (760 mm Hg): 111 C (231 F)
3. Specific gravity (water = 1): 0.86
4. Vapor density (air = 1 at boiling point of toluene): 3.14
5. Melting point: −95 C (−139 F)
6. Vapor pressure at 20 C (68 F): 22 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 0.05
8. Evaporation rate (butyl acetate = 1): 2.24

- Reactivity

1. Conditions contributing to instability: Containers may burst at elevated temperatures.
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon dioxide and carbon monoxide) may be released in a fire involving toluene.
4. Special precautions: Toluene will attack some forms of plastics, rubber, and coatings.

- Flammability

1. Flash point: 4 C (40 F) (closed cup)
2. Autoignition temperature: 480 C (896 F)
3. Flammable limits in air, % by volume: Lower: 1.27; Upper: 7.1
4. Extinguishant: Carbon dioxide, dry chemical, foam

- Warning properties

1. Odor Threshold: The American National Standards Institute (ANSI) states that "the odor of toluene is detectable by most people at concentrations in the range of 10 to 15 ppm. The odor has little value as a warning property."

Patty points out that olfactory fatigue occurs rapidly upon exposure to toluene.

2. Eye Irritation Level: Grant states that "the vapors of toluene cause noticeable sensation of irritation to human eyes at 300 to 400 ppm in air, but even at 800 ppm irritation is slight."

ANSI reports that "irritation of eyes, mucous membranes, and upper respiratory tract may occur while workers are exposed to low concentrations of toluene. There is a considerable range of variation (100 to 500 ppm) between individuals, some finding any concentration of toluene objectionable. Commercial grades of toluene vary in irritant properties."

3. Evaluation of Warning Properties: Because of its irritant effects, toluene is judged to have good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of toluene. Each measurement should consist of a ten (10) minute sample or series of consecutive samples totalling ten (10) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Peak Above Ceiling Evaluation**

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of toluene. Each measurement should consist of a 10-minute sample or a series of consecutive samples totalling 10 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with a subsequent desorption of toluene with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure toluene may be used. An analytical method for toluene is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

Methods for Set V" (order number PB 262 524).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid toluene.
- Any clothing which becomes wet with liquid toluene should be removed immediately and not reworn until the toluene is removed from the clothing.
- Clothing wet with toluene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of toluene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the toluene, the person performing the operation should be informed of toluene's hazardous properties.
- Employees should be provided with and required to use splash-proof safety goggles where liquid toluene may contact the eyes.
- Where there is any possibility that employees' eyes may be exposed to toluene, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes wet with liquid toluene should be promptly washed or showered with soap or mild detergent and water to remove any toluene.
- Employees who handle liquid toluene should wash their hands thoroughly with soap or mild detergent and water before eating or smoking.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to toluene may occur and control methods which may be effective in each case:

Operation	Controls
Use as a solvent in pharmaceutical, chemical, rubber, and plastics industries; as a thinner for paints, lacquer, coatings, and dyes; as a paint remover; insecticides	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use as starting material and intermediate in organic chemical and chemical synthesis industries	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use in manufacture of artificial leather; fabric and paper coatings; photogravure ink production; spray surface coating; as a diluent (cellulose ester lacquers)	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use as constituent in formulation of automotive and aviation fuels	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If liquid toluene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If liquid toluene gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If liquid toluene soaks through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

- Breathing

If a person breathes in large amounts of toluene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- Swallowing

When toluene has been swallowed, get medical attention immediately. Do not attempt to make the exposed person vomit.

- Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If toluene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber. Toluene should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of toluene vapors are permitted.

- Waste disposal method:

Toluene may be disposed of by atomizing in a suitable combustion chamber.

ADDITIONAL INFORMATION

To find additional information on toluene, look up toluene in the following documents:

- Medical Surveillance for Chemical Hazards
- Respiratory Protection for Chemical Hazards
- Personal Protection and Sanitation for Chemical Hazards
- NIOSH Criteria Document for Toluene (July 1973)

These documents are available through the NIOSH Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Toluene," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "Toluene," *Hygienic Guide Series,* Detroit, Michigan, 1957.
- *American National Standard Acceptable Concentrations – Toluene*: ANSI-Z37.12-1974, American National Standards Institute, Inc., New York, 1974.
- American Petroleum Institute: "Toluene," *API Toxicological Reviews,* New York, 1960.
- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List,* 1974 Edition, HEW Publication No. 74-134, 1974.
- Dow Chemical Company: *Material Safety Data Sheet – Toluene,* Midland, Michigan, 1972.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- International Labour Office: *Encyclopedia of Occupational Health and Safety,* McGraw-Hill, New York, 1971.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to Toluene,* HEW Publication No. HSM 73-11023, GPO No. 017-033-00019, U.S. Government Printing Office, Washington, D.C., 1973.
- "Occupational Exposure to Toluene," *Federal Register,* 40:46206-46219, October 6, 1975.
- Patty, F. A. (ed.): *Toxicology,* Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
- Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.
- Union Carbide Corporation, Industrial Medicine and Toxicology Department: *Toxicology Studies – Toluene,* New York, 1970.

Occupational Health Guideline for 1,1,2-Trichloroethane *

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $CHCl_2CH_2Cl$
- Synonyms: Vinyl trichloride; beta-trichloroethane
- Appearance and odor: Colorless liquid with a sweet odor, like chloroform.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for 1,1,2-trichloroethane is 10 parts of 1,1,2-trichloroethane per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 45 milligrams of 1,1,2-trichloroethane per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

1,1,2-Trichloroethane can affect the body if it is inhaled if it comes in contact with the eyes or skin, or if it is swallowed. It may be absorbed through the skin.

- **Effects of overexposure**

1. Short-term Exposure: 1,1,2-Trichloroethane may cause irritation of the eyes and nose, drowsiness, incoordination, unconsciousness, and death. It might also cause liver and kidney damage.

2. Long-term Exposure: Repeated or prolonged exposure to 1,1,2-trichloroethane might cause liver or kidney damage.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to 1,1,2-trichloroethane.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to 1,1,2-trichloroethane at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from 1,1,2-trichloroethane exposure.

—Liver disease: 1,1,2-Trichloroethane causes liver damage in animals and justifies consideration before exposing persons with impaired liver function.

—Kidney disease: 1,1,2-Trichloroethane causes kidney damage in animals and justifies special consideration in those with impaired renal function.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

1,1,2-Trichloroethane vapor is a potent narcotic. Injury to lungs, liver, and kidneys has been observed in animals. The lethal concentration for rats was 2000 ppm for 4 hours. Concentrations resulting in narcosis also caused irritation of the nose and eyes. Mice treated by intraperitoneal injection with anesthetic doses showed moderate hepatic dysfunction and renal dysfunction; at autopsy, there was centrolobular necrosis of the liver and tubular necrosis of the kidney. No human cases of intoxication or systemic effects from industrial exposure have been reported.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 133.4
2. Boiling point (760 mm Hg): 113 C (236 F)
3. Specific gravity (water = 1): 1.43
4. Vapor density (air = 1 at boiling point of 1,1,2-trichloroethane): 4.55
5. Melting point: −37 C (−34 F)
6. Vapor pressure at 20 C (68 F): 18.8 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F):

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

0.45

8. Evaporation rate (butyl acetate = 1): Data not available

- Reactivity

1. Conditions contributing to instability: Heat.

2. Incompatibilities: Contact with strong oxidizers, strong caustics, and chemically active metals such as aluminum and magnesium powders, sodium or potassium may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, phosgene, and carbon monoxide) may be released in a fire involving 1,1,2-trichloroethane.

4. Special precautions: Liquid 1,1,2-trichloroethane will attack some forms of plastics, rubber, and coatings.

- Flammability

1. Flash point: None in normal test method

2. Autoignition temperature: Data not available

3. Flammable limits in air, % by volume: Lower: 6.0; Upper: 15.5 (high energy ignition source required)

4. Extinguishant: Foam, carbon dioxide, dry chemical

- Warning properties

1. Odor Threshold: Although 1,1,2-trichloroethane is known to have a sweet, chloroform-like odor, no quantitative data are available concerning the odor threshold of this substance.

2. Eye Irritation Level: Grant reports that high concentrations of the vapors are irritating to the eyes. The concentrations at which this irritation occurs are not stated.

3. Other Information: Grant reports that high concentrations of the vapors are irritating to the respiratory tract, but no quantitative information is given.

4. Evaluation of Warning Properties: Since no quantitative information is available relating the warning properties to air concentrations of 1,1,2-trichloroethane, this substance has been treated as a material with poor warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- Method

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure 1,1,2-trichloroethane may be used. An analytical method for 1,1,2-trichloroethane is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 5, 1979, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00349-1).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid 1,1,2-trichloroethane.
- Clothing wet with liquid 1,1,2-trichloroethane should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of 1,1,2-trichloroethane from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the 1,1,2-trichloroethane, the person performing the operation should be informed of 1,1,2-trichloroethane's hazardous properties.
- Non-impervious clothing which becomes contaminated with liquid 1,1,2-trichloroethane should be removed promptly and not reworn until the 1,1,2-trichloroethane is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid 1,1,2-trichloroethane may contact the eyes.

SANITATION

- Skin that becomes contaminated with liquid 1,1,2-trichloroethane should be promptly washed or showered with soap or mild detergent and water to remove any 1,1,2-trichloroethane.

- Eating and smoking should not be permitted in areas where liquid 1,1,2-trichloroethane is handled, processed, or stored.
- Employees who handle liquid 1,1,2-trichloroethane should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to 1,1,2-trichloroethane may occur and control methods which may be effective in each case:

Operation	Controls
Use in organic synthesis in production of vinylidene chloride	General dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If 1,1,2-trichloroethane gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If 1,1,2-trichloroethane gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If 1,1,2-trichloroethane soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

- **Breathing**

If a person breathes in large amounts of 1,1,2-trichloroethane, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Swallowing**

When 1,1,2-trichloroethane has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If 1,1,2-trichloroethane is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. Collect for reclamation or absorb in vermiculite, dry sand, or a similar material.

- Waste disposal method:

1,1,2-Trichloroethane may be disposed of by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "1,1,2-Trichloroethane," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- Browning, E.: *Toxicity and Metabolism of Industrial Solvents*, Elsevier, New York, 1965.
- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1971.
- Klaassen, C. D., and Plaa, G. L.: "Relative Effects of Various Chlorinated Hydrocarbons on Liver and Kidney Function in Mice," *Toxicology and Applied Pharmacology*, 9:139-151, 1966.
- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
- Union Carbide Corporation, Industrial Medicine and Toxicology Department: *Toxicology Studies - 1,1,2-Trichloroethane*, New York, 1972.

* SPECIAL NOTE

1,1,2-Trichloroethane appears on the OSHA "Candidate List" of chemicals being considered for further scientific review regarding its carcinogenicity (*Federal Register*, Vol. 45, No. 157, pp. 5372-5379, 12 August 1980).

The International Agency for Research on Cancer (IARC) has evaluated the data on this chemical and has concluded that it causes cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volume 20, 1979.

Occupational Health Guideline for Xylene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $C_6H_4(CH_3)_2$
- Synonyms: Commercial xylene (xylol) is a mixture, mostly the meta-isomer. 1) O-xylene, ortho-xylene, 1,2-dimethylbenzene; 2) m-xylene, meta-xylene, 1,3-dimethylbenzene; 3) p-xylene, para-xylene, 1,4-dimethylbenzene
- Appearance and odor: Colorless liquids with aromatic odors (pure p-xylene is a solid below 12.7 C (55 F)).

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for xylene is 100 parts of xylene per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 435 milligrams of xylene per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 100 ppm averaged over a work shift of up to ten hours per day, forty hours per week, with an acceptable ceiling level of 200 ppm averaged over a 10-minute period. The NIOSH Criteria Document for Xylene should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Xylene can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

1. Short-term Exposure: Xylene vapor may cause irritation of the eyes, nose, and throat. At high concentrations, xylene vapor may cause severe breathing difficulties which may be delayed in onset. At high concentrations, it may also cause dizziness, staggering, drowsiness, and unconsciousness. In addition, breathing high concentrations may cause loss of appetite, nausea, vomiting, and abdominal pain. Liquid xylene may be irritating to the eyes and skin. Exposure to high concentrations of xylene vapor may cause reversible damage to the kidneys and liver.

2. Long-term Exposure: Repeated or prolonged exposure to xylene may cause a skin rash. Repeated exposure of the eyes to high concentrations of xylene vapor may cause reversible eye damage.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to xylene.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to xylene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the central nervous system, eyes, gastrointestinal tract, blood, liver, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders.

—A complete blood count: Xylene has been shown to cause reversible hematopoietic depression in animals. A complete blood count should be performed, including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit.

—Liver function tests: Since liver damage has been observed in humans exposed to xylene, a profile of liver

---

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

function should be obtained by using a medically acceptable array of biochemical tests.

—Urinalysis: Since kidney damage has been observed in humans exposed to xylene, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.

2. *Periodic Medical Examination:* The aforementioned medical examinations should be repeated on a biannual basis.

- **Summary of toxicology**

Xylene vapor irritates the eyes, mucous membranes, and skin; at high concentrations it causes narcosis. In animals, xylene causes blood changes reflecting mild toxicity to the hematopoietic system. Repeated exposure of rabbits to 1150 ppm of a mixture of isomers of xylene for 40 to 55 days caused a reversible decrease in red and white cell count and an increase in thrombocytes; exposure to 690 ppm for the same time period caused only a slight decrease in the white cell count. Three painters working in a confined space of a fuel tank were overcome by xylene vapors estimated to be 10,000 ppm; they were not found until 18.5 hours after entering the tank, and one died from pulmonary edema shortly thereafter; the other two recovered completely in 2 days; both had temporary hepatic impairment (inferred from elevated serum transaminase levels) and one of them had evidence of temporary renal impairment (increased blood urea and reduced creatinine clearance). In humans, exposure to undetermined but high concentrations caused dizziness, excitement, drowsiness, incoordination and a staggering gait. Workers exposed to concentrations above 200 ppm complain of anorexia, nausea, vomiting, and abdominal pain. Brief exposure of humans to 200 ppm caused irritation of the eyes, nose, and throat. There are reports of reversible corneal vacuolation in workers exposed to xylene, or to xylene plus other volatile solvents. The liquid is a skin irritant and causes erythema, dryness, and defatting; prolonged contact may cause the formation of vesicles.

CHEMICAL AND PHYSICAL PROPERTIES

Data in the following section are presented for xylene's three isomers: 1) ortho, 2) meta, and 3) para.

- **Physical data**

1. Molecular weight: 106.2

2. Boiling point (760 mm Hg): 1) 144.4 C (292 F); 2) [illegible] C (282 F); 3) 138.3 C (281 F)

3. Specific gravity (water = 1): 1) 0.88; 2) 0.86; 3) 0.86

4. Vapor density (air = 1 at boiling point of xylene): 3.7

5. Melting point: 1) −25 C (−12 F); 2) −48 C (−54 F); 3) 13 C (55 F)

6. Vapor pressure at 20 C (68 F): 1) 7 mm Hg; 2) 9 mm Hg; 3) 9 mm Hg

7. Solubility in water, g/100 g water at 20 C (68 F): 1) 0.00003; 2) 0.00003; 3) 0.00003

8. Evaporation rate (butyl acetate = 1): 1) 0.7; 2) 0.7; 3) 0.7

- **Reactivity**

1. Conditions contributing to instability: Elevated temperatures may cause containers to burst.

2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving xylene.

4. Special precautions: Xylene will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Flash point: 1) 32 C (90 F) (closed cup); 2) 28.9 C (84 F); 3) 27.2 C (81 F)

2. Autoignition temperature: 1) 465 C (869 F); 2) 530 C (986 F); 3) 530 C (986 F)

3. Flammable limits in air, % by volume: Lower: 1) 1.0; 2) 1.1; 3) 1.1; Upper: 1) 6.0; 2) 7.0; 3) 7.0

4. Extinguishant: Foam, carbon dioxide, dry chemical

- **Warning properties**

1. Odor Threshold: Patty states that "the initial odor of 200 ppm has an intensity of approximately 3 and an irritation value of 1. As in most other instances, olfactory fatigue occurs rapidly and the odor is no longer detected at this concentration."

2. Eye Irritation Level: The AIHA *Hygienic Guide* states that "exposure to vapors at 200 ppm caused eye irritation in most of the persons tested. Lesions in the form of fine vacuoles in the cornea of cats exposed to commercial xylene vapors have been observed."

3. Other Information: The *Handbook of Industrial Organic Chemicals* states that xylene "may be irritating to eyes, nose and throat as exposure exceeds threshold limit." The *Hygienic Guide* notes that 200 ppm causes irritation of the nose and throat.

4. Evaluation of Warning Properties: Through its irritant effects, xylene can be detected within three times the permissible exposure limit. For the purposes of this guideline, therefore, xylene is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of xylene. Each measurement should consist of a ten (10) minute sample or series of consecutive samples totalling ten (10) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- Method

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure xylene may be used. An analytical method for xylene is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid or solid xylene.
- Clothing contaminated with xylene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of xylene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the xylene, the person performing the operation should be informed of xylene's hazardous properties.
- Any clothing which becomes wet with liquid xylene should be removed immediately and non-impervious clothing which becomes contaminated with xylene should be removed promptly and not reworn until the xylene is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid or solid xylene may contact the eyes.

SANITATION

- Skin that becomes contaminated with xylene should be promptly washed or showered with soap or mild detergent and water to remove any xylene.
- Employees who handle liquid or solid xylene should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to xylene may occur and control methods which may be effective in each case:

Operation	Controls
Use as an intermediate during manufacture of plastics, synthetic fibers, and mixed/pure isomers	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment
Use as diluent or solvent in surface coatings, printing operations, and manufacture of rubber; degreasing agent in plastics and electronics manufacture; in organic synthesis reactions and manufacture of epoxy resins	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment
Use in formulation of insecticides	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment
Use in manufacture of xylene-formaldehyde resins; pharmaceuticals, vitamins, leather; and as a sterilizing agent for cat-gut and in microscopy	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment

Operation	Controls
Use during blending of motor and aviation fuels	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- Eye Exposure

If liquid or solid xylene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- Skin Exposure

If liquid or solid xylene gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If liquid or solid xylene penetrates through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation is present after washing, get medical attention.

- Breathing

If a person breathes in large amounts of xylene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- Swallowing

When xylene has been swallowed, do not induce vomiting. Get medical attention immediately.

- Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If xylene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber. Xylene should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of xylene vapors are permitted.
4. If the solid form, allow to melt and treat as in (3) above.

- Waste disposal method:

Xylene may be disposed of by atomizing in a suitable combustion chamber.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Xylene," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "Xylene," *Hygienic Guide Series*, Detroit, Michigan, 1971.
- *American National Standard Acceptable Concentrations – Xylene*: ANSI-Z37.10-1971, American National Standards Institute, Inc., New York, 1971.
- American Petroleum Institute: "Xylene," *API Toxicological Reviews*, New York, 1960.
- Browning, E.: *Toxicity and Metabolism of Industrial Solvents*, Elsevier, New York, 1965.
- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.
- Deichmann, W. B., and Gerarde, H. W.: *Toxicology of Drugs and Chemicals*, Academic Press, New York, 1969.
- Dow Chemical Company: *Material Safety Data Sheet – Xylene*, Midland, Michigan, 1973.
- Gerarde, H. W.: *Toxicology and Biochemistry of Aromatic Hydrocarbons*, Elsevier, Amsterdam, 1960.
- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products5(3rd ed.), Williams and Wilkins, Baltimore, 1969.*
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- *Handbook of Organic Industrial Solvents*, Technical Guide No. 6 (4th ed.), American Mutual Insurance Alliance, Chicago, 1972.
- *Hygienic Information Guide No. 31 – Xylene*, Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Occupational Health, 1972.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to Xylene*, HEW Publication No. (NIOSH) 75-168, GPO No. 017-033-00075, U.S. Government Printing Office, Washington, D.C., 1975.
- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
- Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

APPENDIX C

HEAT STRESS

HEAT STRESS

1.0 INTRODUCTION

Heat stress is the aggregate of environmental and physical work factors that make up the total heat load imposed on the body. The environmental factors of heat stress include air temperature, humidity, radiant heat exchange, wind, and water vapor pressure (related to humidity). Physical work contributes to the total heat stress by producing metabolic heat in the body, proportional to the intensity of the work.

Heavy physical labor can greatly increase the likelihood of fatigue, heat exhaustion, and heat stroke, the latter being a life threatening condition. All employees are to be alert to the possibility and symptoms of heat stress. Should the employee experience extreme fatigue, cramps, dizziness, headache, nausea, profuse sweating, or pale clammy skin, the employee and the SSO are to take control measures. If the symptoms do not subside after a reasonable rest period, the SSO shall seek medical assistance.

2.0 STANDARD OPERATING PROCEDURES FOR THE CONTROL OF HEAT STRESS

2.1 Use of Chemical Protective Clothing (CPC) Above 75°F

A. Training and Acclimatization

All workers assigned to work tasks which require the use of personal protective equipment in temperatures exceeding 75°F are to be trained in the recognition and treatment of heat stress-related health effects.

Under such conditions, workers will be given the opportunity to become acclimated to the heat through an acclimatization schedule beginning with 50 percent of the workload which will be increased by 10 percent daily over a 6-day period. This schedule will be implemented at the discretion of the site safety coordinator based on the actual temperature and physical exertion required; however, the acclimatization plan is mandatory for workers which have not been in the field for 4 or more weeks and temperatures are in excess of 85°F (29.5°C).

B. Monitoring

A dry bulb thermometer or a wet bulb globe temperature (WBGT) weather station should be in operation at all waste sites when workers are suited up and temperatures exceed 75°F. All WBGT or dry bulb readings are to be recorded in the daily health and safety log.

Pulse rates will be taken and recorded at the beginning of each rest period. Skin temperature may also be measured after each work cycle and recorded during temperatures in excess of 85°F.

Pulse rate is a fairly easy and accurate method for assessing heat stress. The pulse rate should be used in conjunction with the worker's own assessment of his overall well-being to control heat stress, in the absence of regular guidance. The method for determining a maximum allowable pulse rate is as follows:

a.) Determine the individual's maximum heart (pulse) rate in beats per minute using the following formula:

Maximum = 220 beats/minute - years in age.

b.) Determine the individuals target heart rate (HR) at 60% of the maximum heart rate using the following formula:

Target = Maximum HR x 0.6

c.) Take a thirty or sixty second pulse rate count to determine the heart rate in beats per minute. If the pulse rate exceeds the target heart rate, the individual should be allowed to rest until his pulse drops to approximately 40% of the Maximum (maximum x 0.4).

d.) The HR at the beginning of the rest period should not exceed 110 beats/minute. If the HR is higher, the next work shift should be shortened by 33%, while the length of the rest period stays the same. If the pulse rate still exceeds 110 beats/minute at the beginning of the next rest period, the following work cycle should be further shortened by 33%. This procedure is continued until the rate is maintained below 110 beats/minute.

C. Work-Rest Regimens

The following work-rest regimen will be adopted unless contraindicated by the action levels stated:

Water Intake, Work-Rest Cycles for Essential
Field Operation (Which Cannot Be Curtailed)
For Heat-Acclimated Fit Workers

Heat Condition	Botsball WGT (°F)[a]	Water Intake (qt/hr)	Work-Rest Cycles (min)
Green	80 - 83	0.5 - 1.0	50/10
Yellow	83 - 86	1.0 - 1.5	45/15
Red	86 - 90	1.5 - 2.0	30/30
Black	90 and above	2.0	20/40[b]

[a] To convert WGT to WBGT, add 2°F. Below 80°F, drink up to 0.5 qt/hr, 50/10 work-rest cycles.

[b] Depending on condition of the worker.

To Maintain Physical Performance:

1. Drink 1 quart of water in the a.m., at each meal, and before any hard work. (The addition of electrolytes may be necessary to prevent heat cramps.)
2. Take frequent drinks since they are more effective than all at once. Larger workers need more water.
3. Replace salt loss by eating three meals per day.
4. As the WGT increases, rest periods must be more frequent, work rate lowered, and loads reduced.
5. Use water as a key element to maintain top efficiency by drinking each hour.

Safe "Closed" Suit Times for
Moderate Work
(300 w; 250 kcal/hr)

Ambient Air (a) Temperature (°F)	Wearing Time (Closed)
30 or less	8 hours
30 - 50	5 hours
50 - 60	3 hours
60 - 70	2 hours
70 - 80	90 minutes
80 - 85	60 minutes
85 - 90	30 minutes
90 or above	15 minutes

From Ralph F. Goldman, Ph.D.
Protecting Personnel at Hazardous Waste Sites

A rest area will be established out of direct sunlight, ideally with a temperature of 75°F. Cool drinking water and a spray hose for cooling the protective garments will be available.

When temperatures exceed a WBGT of 90°F, half-day shifts are advised, consisting of an early morning a.m. team and a late afternoon-evening p.m. team.

Showers should be available on-site.

D. Protective Clothing

Poly-coated tyveks and saranex will only be issued as necessary to protect against skin exposure to toxic or unknown concentrations of liquids and gases. Semi-permeable coveralls will be used for nontoxic concentrations of particulates and gases.

Thin cotton garments are to be worn under all protective suits to absorb perspiration.

Cooling devices such as ice vests and vortex suits may serve as a method of cooling individuals. These devices may be special ordered at the request and expense of the project manager.

E. Miscellaneous

Workers over 45 years of age should be discouraged from performing work in impermeable garments under stress monitoring conditions.

Work crews should be provided with feasible engineering controls which reduce heat stress, including shading from direct sunlight and cooling of confined spaces.

2.2 Permissible Heat Exposure for Level D Workers (Adapted from the ACGIH Heat Exposure TLVs)

A. Training and Acclimatization

All workers assigned to Level D work tasks in environments exceeding 85°F (30°C) are to be trained in the recognition and treatment of heat stress-related health effects.

Under such conditions, workers will be given the opportunity to become acclimated to the heat through an acclimatization schedule beginning with 50 percent of the workload which will be increased by 10 percent daily over a 6-day period. This schedule will be implemented at the discretion of the site safety coordinator based on the actual temperature and physical exertion required; however, the acclimatization plan is mandatory for workers which have not been in the field for 4 or more weeks and temperatures are in excess of 85°F (29.5°C).

B. Monitoring

Due to the variable effects of humidity and solar load, the wet bulb globe temperature system is recommended for temperatures exceeding 85°F (30°C). WBGT temperatures are determined by the following formulas:

1). Outdoor with solar load
WBGT = 0.7 NWB + 0.2 GT + 0.1 DB

2.) B. Indoors or outdoors with no solar load
WBGT = 0.7 NWB + 0.3 GT, where:

WBGT = Wet Bulb Globe Temperature
NWB = Natural Wet Bulb Temperature
DB = Dry Bulb Temperature
GT = Globe Temperature

C. Work-Rest Regimen

The following work-rest regimen is recommended for Level D work:

Permissible Heat Exposure Threshold Limit Values
(Values are Given in °C WBGT)

	Work Load		
Work-Rest Regimen	Light	Moderate	Heavy
Continuous Work	30.0	26.7	25.0
75% Work-25% Rest, Each hour	30.6	28.0	27.9
50% Work-50% Rest, Each hour	31.4	29.4	27.9
25% Work-75% Rest, Each hour	32.2	31.1	30.0

The recommendations identified in Subpart A under "Maintaining Physical Performance" pertain to Level D work also.

D. Miscellaneous

Cooling devices are available through special order. Workers over 45 years of age should be discouraged from conducting heavy work in hot environments.

APPENDIX D

COLD STRESS

COLD STRESS

1.0 INTRODUCTION

Persons working outdoors in low temperatures are subject to cold stress, especially if the temperature is at or below freezing. Exposure to cold for a short period of time can cause severe injury to the surface of the body (frostbite), or result in profound general cooling, potentially resulting in hypothermia and death. Areas of the body which have high surface area to volume ratios such as fingers, toes, and ears are the most susceptible. In general, the body's response to cold stress progresses from frostbite (incipient, superficial, and deep frostbite) to hypothermia. Recognition of the symptoms of cold stress is essential to worker protection when operating in low temperatures.

2.0 FROSTBITE

Local injury resulting from cold is included in the generic term "frostbite" or the freezing of tissues. The only warning symptoms may be a sudden blanching of the skin and a tingling, stinging, or dull sensation in the affected parts, followed by numbness. When tissue temperature drops to -20°F, frostbite generally occurs. Frostbite most commonly affects the hands, feet, ears, cheeks, and nose.

In the event that a frostbite injury occurs, take the exposed employee indoors and rewarm the areas quickly in warm water that is between 102-105°F, for about twenty minutes or until the frozen part is red in color. Provide warm drinks, but no coffee, tea or alcohol. Keep the affected (frozen) parts in warm water or covered with warm clothing for 30 minutes, even though the tissue will be very painful as it thaws. If present, do not allow blisters to be broken. Use sterile, soft, dry material to cover the injured area; keep the patient warm and seek medical attention.

- Do not rub the frostbitten part (this may cause gangrene);
- Do not use ice, snow, gasoline, or anything cold on the frostbitten area;
- Do not use heat lamps, hot water bottles, or stoves, to rewarm the frostbitten areas.

3.0 HYPOTHERMIA

Hypothermia is defined as a lowering of the central (core) body temperature. General hypothermia, the most life threatening cold injury, affects the entire body system. Once the body temperature is lowered to 95°F, thermal control is lost, and the body is no longer in thermal balance. Coma occurs when the body's core temperature reaches approximately 79°F. Death can occur within two hours of the first signs and symptoms. The general symptoms of hypothermia are usually exhibited in five stages:

- Shivering;
- Apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body;
- Unconsciousness, glassy stare, slow pulse and respiratory rate;
- Freezing of the extremities; and
- Death.

Extremely low temperatures are not necessary to induce hypothermia. Hypothermia can occur in temperatures as high as 65°F, depending on the wind chill factor. Wind increases the body's heat loss by dispersing layers of warm air trapped between layers of clothing and skin. This heat loss increases as the wind speed increases. Table B-1 presents the combined effect of wind and temperature in terms of an equivalent effective temperature acting upon exposed flesh. The wind chill chart applies only to exposed flesh; any clothing or material that reduces or stops the wind, protects the area it covers to some extent.

4.0 EVALUATION AND CONTROL

Threshold Limit Values (TLVs) are intended to protect workers from the severest effects of cold stress (hypothermia) and cold injury (frostbite) and to describe exposures to cold working conditions under which it is believed that workers can be repeatedly exposed without adverse health effects. The TLV objective is to prevent deep body core temperature from falling below 36°C (96.8°F) and to prevent cold injury to body extremities. Deep body temperature is the core temperature of the body as determined by rectal temperature measurements. For a single, occasional exposure to a cold environment, a drop in core temperature to not lower than 35°C should be permitted. In addition to provisions for total body protection, the TLV objective is to protect all parts of the body with emphasis on hands, feet, and head from cold injury.

For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -32°C (-25°F). Superficial or deep local tissue freezing will occur only at temperatures below -1°C regardless of wind speed.

At air temperatures of 2°C (35.6°F) or less, it is imperative that workers who become immersed in water or whose clothing becomes wet, be immediately provided a change of clothing and be treated for hypothermia.

Recommended limits for properly clothed workers for periods of work at temperatures below freezing are shown in Table B-2.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents:

1. If fine work is to be performed with bare hands for more than 10-20 minutes in an environment below 16°C (60°F), special provisions should be established for keeping the workers' hands warm. For this purpose, warm air jets, radiant heaters (fuel burner or electric radiator), or contact warm plates may be utilized. Metal handles on tools and control bars shall be covered by thermal insulating materials at temperatures below -1°C (30°F).

2. If the air temperature falls below 16°C (60°F) for sedentary, 4°C (40°F) for light, -7°C (20°F) for moderate work and fine manual dexterity is not required, then gloves shall be used the workers.

To prevent contact frostbite, the workers should wear anti-contact gloves.

1. When cold surfaces below -7°C (20°F) are within reach, a warning should be given to each worker by his supervisor to prevent inadvertent contact with bare skin.

2. If the temperature is -17.5°C (0°F) or less, the hands should be protected by mittens. Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

Provisions for additional total body protection are required is work is performed in an environment at or below 4°C (20°F). The workers shall wear cold protective clothing appropriate for the level of cold and physical activity.

1. If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind shall be reduced by shielding the work area, or by wearing an easily removable outer windbreak layer garment.

2. With more severe work, the outer wear should be changed as it becomes wet. If work is done at normal temperatures in a hot environment before entering the cold area, the employee shall make sure that his clothing is not wet as a consequence of sweating. If his clothing is wet, the employee shall change into dry clothing before entering the cold area. The workers shall change socks and any removable felt insoles at regular daily intervals or use vapor barrier boots. The optimal frequency of change shall be determined empirically and will vary individually and according to the type of shoe worn and how much the individual's feet sweat.

3. Extremities, ears, toes, and nose shall be protected sufficiently to prevent sensation of excessive cold or frostbite by handware, footware, and face masks.

4. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work shall be modified or suspended until adequate clothing is made available or until weather conditions improve.

5. Workers handling evaporative liquid (gasoline, alcohol or cleaning fluids) at air temperatures below 4°C (40°F) shall take special precautions to avoid soaking of clothing or gloves with the liquids because of the added danger of cold injury due to evaporative cooling. Special note should be taken of the particularly acute effects of splashes of "cryogenic fluids" or those liquids with a boiling point only just above ambient temperatures.

5.0 WORK-WARMING REGIMEN

If work is performed continuously in the cold at an equivalent chill temperature (ECT) of below -7°C (20°F), heated warming shelters (tents, cabins, rest rooms, etc.) shall be made available nearby and the workers should be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing shall be removed and the remainder of the clothing loosened to permit sweat evaporation or a change of dry work clothing provided. A change of dry work clothing shall be provided as necessary to prevent workers from returning to their work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below -12°C (10°F) ECT, the following shall apply:

1. The worker shall be under constant protective observation (buddy system or supervision).

2. The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods must be taken in heated shelters and opportunity for changing into dry clothing shall be provided.

3. New employees shall not be required to work full-time in cold in the first days until they become accustomed to the working conditions and required protective clothing.

4. The weight and bulkiness of clothing shall be included in estimating the required work performance and weights to be lifted by the worker.

5. The work shall be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats shall not be used. The worker should be protected from drafts to the greatest extent possible.

6. The workers shall be instructed in safety and health procedures. The training program shall include, as a minimum, instruction in:

   a. Proper rewarming procedures and appropriate first aid treatment.

   b. Proper clothing practices.

   c. Proper eating and drinking habits.

   d. Recognition of impending frostbite.

   e. Recognition of signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur.

   f. Safe work practices.

6.0 SPECIAL WORKPLACE RECOMMENDATIONS

Eye protection for workers employed out-of-doors in a snow and/or ice-covered terrain shall be supplied. Special safety goggles to protect against ultraviolet light and glare (which can produce temporary conjunctivitis and/or temporary loss of vision) and blowing ice crystals are required when there is an expanse of snow coverage causing a potential eye exposure hazard.

Workplace monitoring is required as follows:

1. Suitable thermometry should be arranged at any workplace where the environmental temperature is below 16°C (60°F) to enable overall compliance with the requirements of the TLV to be maintained.

2. Whenever the air temperature at a workplace falls below -1°F (30°F), the dry bulb temperature should be measured and recorded at least every 4 hours.

3. In outdoor work situations, the wind speed should be measured and recorded together with the air temperature whenever the air temperature is below -1°C (30°F).

4. The equivalent chill temperature shall be obtained from Table 2 in all cases where air movement measurements are required, and shall be recorded with the other data whenever the equivalent chill temperature is below -7°C (20°F).

Employees shall be excluded from work in cold at -1°C (30°F) or below if they are suffering from diseases or taking medication which interferes with normal body temperature regulation or reduces tolerance to work in cold environments. Workers who are routinely exposed to temperatures below -24°C (0°F) with winds speeds above five miles per hour, should be medically certified as suitable for such exposures.

Trauma sustained in freezing or subzero conditions requires special attention because an injured worker is predisposed to secondary cold injury. Special provisions must be make to prevent hypothermia and secondary freezing of damaged tissues in addition to providing for first aid treatment.

APPENDIX E

AIR MONITORING INSTRUMENT CALIBRATION PROCEDURES

CALIBRATION PROCEDURES FOR THE MSA PHOTON PHOTOIONIZATION DETECTOR

1. Turn on instrument and allow it to warm up.
2. Press the CAL button and expose the instrument to the zero gas (normal air).
3. Press ENTER to zero the instrument on the zero gas.
4. The instrument then asks for the Span Gas concentration. The Span Gas is Isobutylene at 100 ppm. Enter 100 ppm and connect the probe to the Span Gas.
5. Press ENTER and allow the instrument to detect the Span Gas.
6. When the display reads 100 ppm, remove the Span Gas.
7. The instrument is now ready for use.

CALIBRATION PROCEDURES FOR THE MSA COMBUSTIBLE GAS INDICATOR, MODEL 261

1. Open the instrument lid and turn the center ON-OFF control to the HORN OFF position. Both meter pointers will move and one or both Alarms may light.

2. Set the % LEL meter pointer to zero by adjusting the ZERO LEL control. Adjustment should be make within 30 seconds after the instrument is turned on; this is to prevent accidental activation of the meter latch circuit.

3. If the % oxygen meter pointer stabilizes at a value other than 20.8%, the pointer should be set to 20.8% by using the CALIBRATE O_2 control.

4. Press the ALARM RESET button; the Alarm(s) should reset and the green pilot light should flash.

5. Momentarily place a finger over the sample inlet fitting or the end of the sample line probe. Observe that the flow indicator float drops out of sight, indicating no flow. If the float does not drop, check the flow system for leaks as described in the Instruction Manual.

6. Press the CHECK button and observe the % LEL meter. The pointer must read 80% LEL or higher as marked by the BATTERY zone on the meter. If the pointer reading is less, the battery pack must be recharged; no tests should be attempted as the instrument will malfunction.

7. Turn the ON-OFF control to the ON position. The pilot lamp should light continuously.

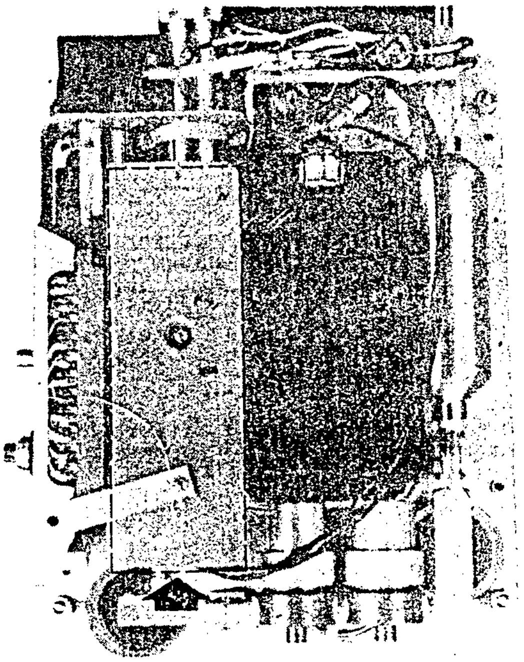
8. Select the % LEL screen and attach the calibration gas to the inlet of the instrument. The calibration gas is Pentane at 0.75% in air (equivalent to 50% of the LEL).

9. The instrument should read anywhere between 45-50% of the LEL on the % LEL meter.

10. If the instrument does not read between 45-50% of the LEL, adjust the set screw on the instrument according to the Instruction Manual.

CALIBRATION PROCEDURES FOR THE FOXBORO ORGANIC VAPOR ANALYZER, MODEL OVA 128

1. Place the instrument in normal operation with the CALIBRATE Switch set to X10 and the GAS SELECT control set to 300.
2. Use the CALIBRATE ADJUST (zero knob) to adjust the meter reading to zero.
3. Introduce a methane sample of a known concentration (between 90 and 100 ppm, not to exceed 100 ppm) and adjust trimpot R-32 (see figure below) so the meter reading corresponds to the known sample.
4. This sets the instrument gain for methane with the panel mounted gain adjustment (GAS SELECT) set at a reference number of 300.
5. Turn off the HYDROGEN SUPPLY VALVE to put out the flame.
6. Leave CALIBRATE Switch on X10 position and use CALIBRATE ADJUST (zero) Knob to adjust the meter reading to 4 ppm.
7. Place CALIBRATE Switch to X1 position and using trimpot R-31 adjust the meter reading to 4 ppm.
8. Move CALIBRATE Switch to X10 position again. Use CALIBRATE ADJUST (zero) Knob to adjust meter to a reading of 40 ppm.
9. Move CALIBRATE Switch to X100 position and use trimpot R-33 to adjust the meter reading to 40 ppm.
10. Move CALIBRATE ADJUST (zero) Knob to adjust the meter reading to zero.
11. The instrument is now ready for use.



R-31 R-32 R-33 R-38

APPENDIX F

DECONTAMINATION PROCEDURES

DECONTAMINATION PROCEDURES

1) Locate a decontamination area between the Hot Line (upwind boundary of the Exclusion Area) and the Clean Area boundary.

2) Establish a personnel decontamination station (PDS). (See attached procedures for layout and closure).

3) Upon leaving the contamination area, all personnel will proceed through the appropriate Contamination Reduction Sequence as described above.

4) All protection gear should be left on-site during lunch break following decontamination procedures.

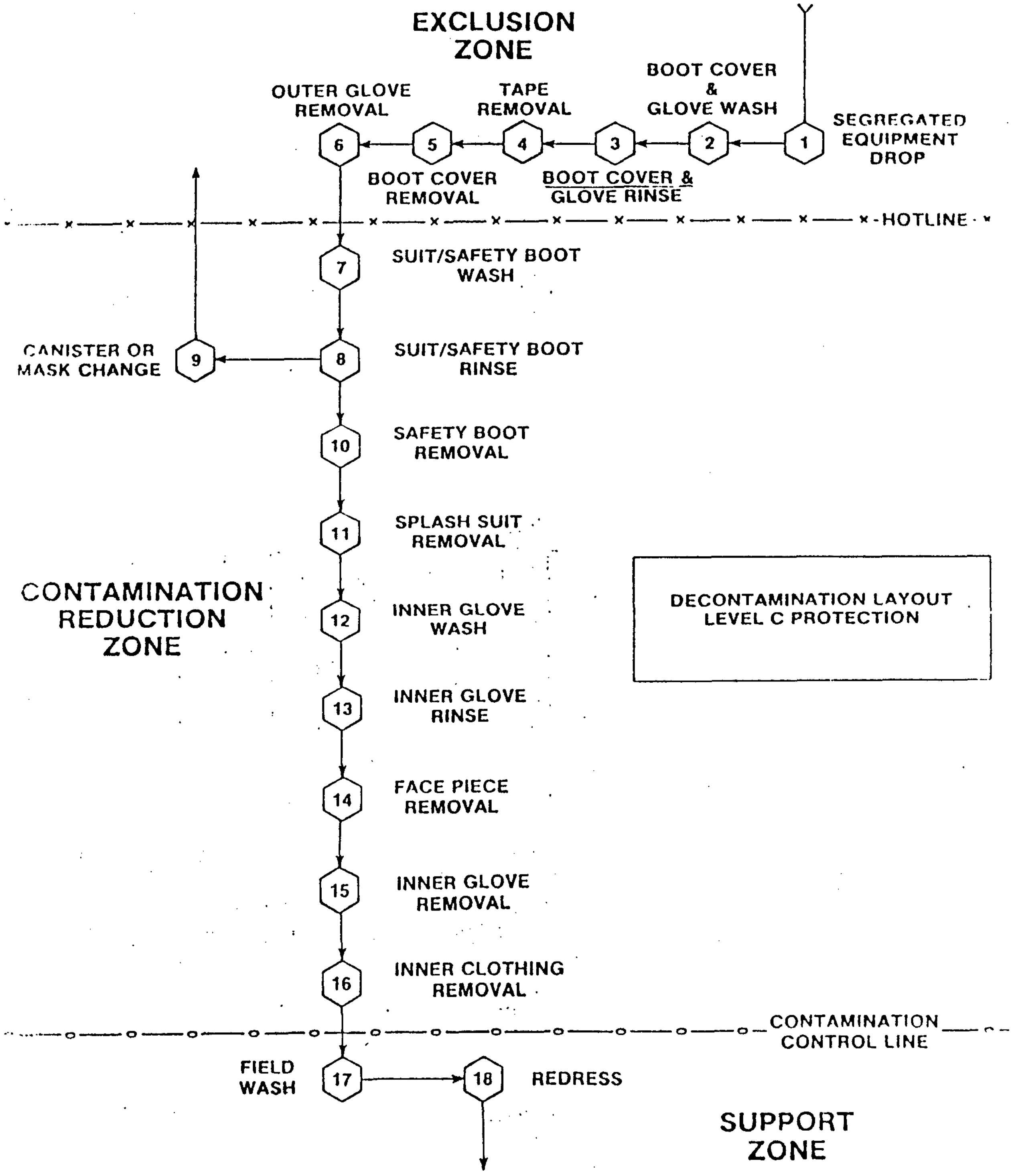
MAXIMUM MEASURES FOR LEVEL C DECONTAMINATION

Station 1:	Segregated Equipment Drop	1.	Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc) on plastic drop cloths or in different containers with plastic liners. Segregation at the drop reduces the probability of cross-contamination. During hot weather operations, a cool down station may be set up within this area.
Station 2:	Boot Cover and Glove Wash	2.	Scrub outer boot covers and gloves with decon solution or detergent and water.
Station 3:	Boot Cover and Glove Rinse	3.	Rinse off decon solution from Station 2 using copious amounts of water.
Station 4:	Tape Removal	4.	Remove tape around boots and gloves and deposit in container with plastic liner.
Station 5:	Boot Cover Removal	5.	Remove boot covers and deposit in containers with plastic liner.
Station 6:	Outer Glove Removal	6.	Remove outer gloves and deposit in container with plastic liner.
Station 7:	Suit and Boot Wash	7.	Wash splash suit, gloves, and safety boots. Scrub with long-handle scrub brush and decon solution.
Station 8:	Suit, Boot and Glove Rinse	8.	Rinse off decon solution using water. Repeat as many times as necessary.

MAXIMUM MEASURES FOR LEVEL C DECONTAMINATION (Continued)

Station 9:	Canister or Mask Change	9.	If worker leaves exclusion zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boot covers donned, and joints taped. Worker returns to duty.
Station 10:	Safety Boot Removal	10.	Remove safety boots and deposit in container with plastic liner.
Station 11:	Splash Suit Removal	11.	With assistance of helper, remove splash suit. Deposit in container with plastic liner.
Station 12:	Inner Glove Wash	12.	Wash inner gloves with decon solution.
Station 13:	Inner Glove Rinse	13.	Rinse inner gloves with water.
Station 14:	Face Piece Removal	14.	Remove face piece. Deposit in container with plastic liner. Avoid touching face with fingers.
Station 15:	Inner Glove Removal	15.	Remove inner gloves and deposit in lined container.
Station 16:	Inner Clothing Removal	16.	Remove clothing soaked with perspiration and place in lined container. Co not wear inner clothing off-site since there is a possibility that small amounts of contaminants might have been transferred in removing the fully-encapsulating suit.
Station 17:	Field Wash	17.	Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.
Station 18	Redress	18.	Put on clean clothes

MAXIMUM DECONTAMINATION LAYOUT FOR LEVEL C PROTECTION



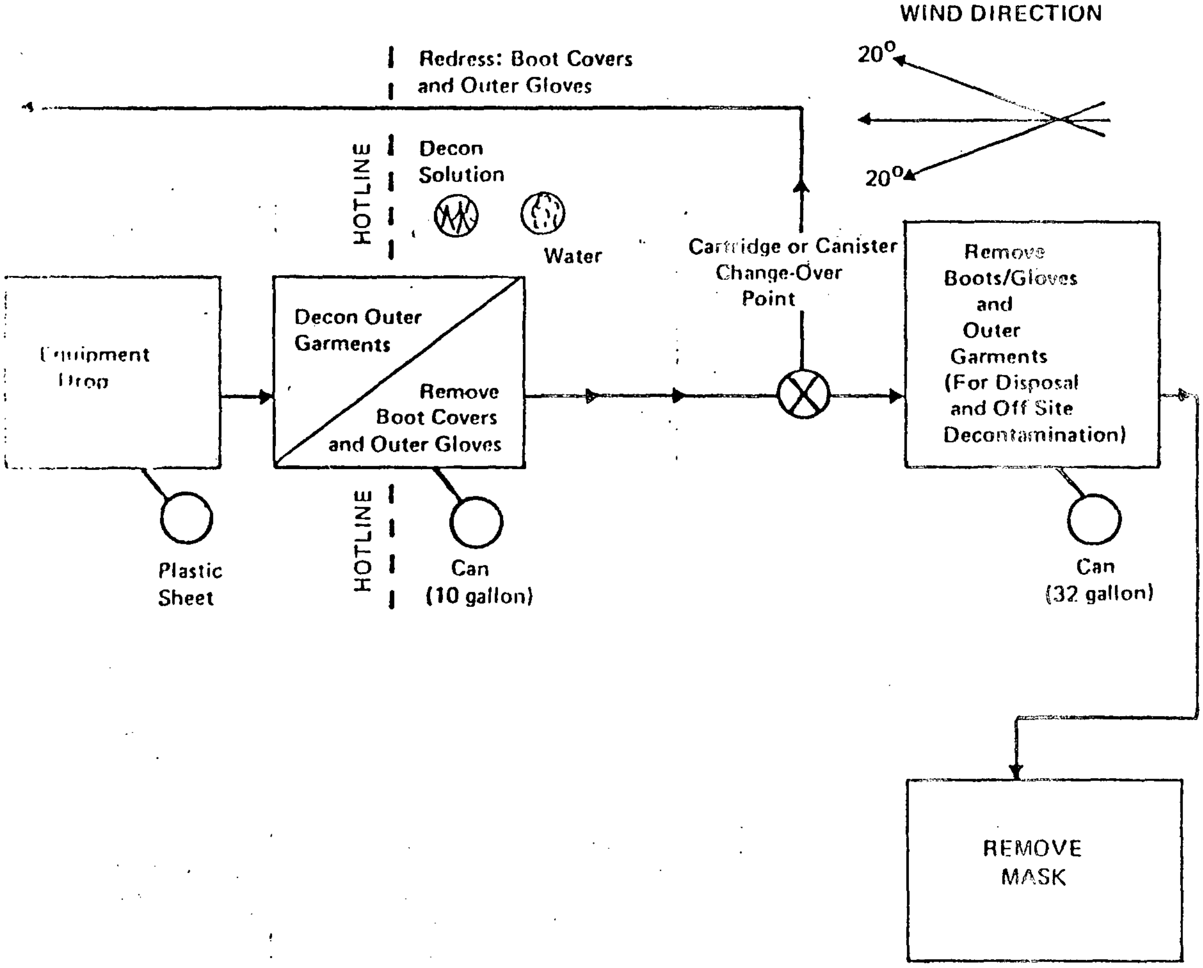
MINIMAL DECONTAMINATION

Less extensive procedures for decontamination can be subsequently or initially established when the type and degree of contamination becomes known or the potential for transfer is judged to be minimal. These procedures generally involve one or two washdowns only. The layout for a minimal decontamination operation is shown in the attached diagram.

MINIMUM MEASURES FOR LEVEL C DECONTAMINATION

Station 1:	Equipment Drop	1.	Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths. Segregation at the drop reduces the probability of cross-contamination. During hot weather operations, a cool-down station may be set up within this area.
Station 2:	Outer Garment, Boots, and Gloves Wash and	2.	Scrub outer boots, outer gloves and splash suit with decon solution or detergent water. Rinse off using copious amounts of water.
Station 3:	Outer Boot and Glove Removal	3.	Remove outer boots and gloves. Deposit in container with plastic liner
Station 4:	Canister or Mask Change	4.	If worker leaves exclusion zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.
Station 5:	Boot, Gloves and Outer Garment Removal	5.	Boots, chemical-resistant splash suit, inner gloves removed and deposited in separate containers lined with plastic.
Station 6:	Face Piece Removal	6.	Face piece is removed. Avoid touching face with fingers. Facepiece deposited on plastic sheet.
Station 7:	Field Wash	7.	Hands and face are thoroughly washed. Shower as soon as possible.

MINIMUM DECONTAMINATION LAYOUT FOR LEVEL C PROTECTION



CLOSURE OF THE PERSONNEL DECONTAMINATION STATION

All disposable clothing and plastic sheeting used during the operation should be double-bagged and either contained on site or removed to an approved off-site disposal facility. Decon and rinse solution could be discarded on site or removed to an approved disposal facility. Reusable rubber clothing should be dried and prepared for future use. (If gross contamination had occurred, additional decontamination of these items may be required). Cloth items should be bagged and removed from the site for final cleaning. All wash tubs, pail containers, etc., should be thoroughly washed, rinsed, and dried prior to removal from the site.

APPENDIX G

PERSONAL PROTECTIVE EQUIPMENT PROGRAM

RESPIRATORY PROTECTION PROGRAM

1.0 INTRODUCTION

This program has been developed to govern the selection and use of respiratory protective devices by Fort Douglas RI/FS personnel. The program is intended to comply with Occupational Safety and Health Administration (OSHA) requirements as set forth in 29 CFR 1910.134(b). The scope of this program is limited to activities related to field investigations of potentially hazardous waste disposal sites.

2.0 PERSONNEL REQUIREMENTS

No personnel will be assigned duties which require a respirator when facial hair, skullcaps, or eye glasses will interfere with a proper fit. No contact lenses may be worn with any respirator protective device. Eyeglass frames which fit inside the respirator facepiece will be utilized as necessary.

3.0 APPLICABLE EQUIPMENT

The following equipment is available for site tasks:

- half-face chemical air purifying respirator
- full-face chemical/mechanical air purifying respirator

This equipment is intended for use on an as needed basis, to be determined by an evaluation of on-site conditions.

Selection criteria are presented separately; training is required in the use of each type of equipment prior to use.

4.0 PERSONNEL TRAINING

Training of personnel in the proper use and care of respiratory protective equipment is considered essential to the success of the program. Training encompasses:

- respiratory protection principles
- selection of appropriate equipment
- use of equipment
- maintenance of equipment
- fit testing

Information regarding each topic is presented as standard respiratory protection procedures.

5.0 STANDARD RESPIRATORY PROTECTION PROCEDURES

The following information has been organized and presented by topic as Standard Respiratory Protection Procedures, to be used both in training and as reference material for field operations.

Standard Respiratory Protection Procedure No.	Topic
1	Respiratory Protection Principles
2	Selection of Respirators
3	Fit Testing
4	Inspection/Maintenance/Storage

These procedures are attached.

6.0 PROGRAM ADMINISTRATION AND DOCUMENTATION

The administration of Fort Douglas RI/FS Project Respiratory Protection Program is the responsibility of the Health and Safety Manager. Administration includes:

- respirator selection
- personnel training
- fit testing
- respirator maintenance
- documentation
- program evaluation and improvements

Written HASPs for each site, and site hazard assessments result in respirator selection in accordance with the decision logic set forth in Standard Respirator Protection Procedure No. 2.

Fit testing and respirator maintenance is performed by the Site Health & Safety Officer under the administration of the Health & Safety Manager.

Major maintenance is performed by manufacturer certified technicians only. Personnel training in respiratory protection is one aspect of the Health & Safety Manager's ongoing personnel training programs.

Program evaluation is a dynamic process, occurring each time a project's tasks are modified.

Medical surveillance is required for all personnel assigned to hazardous site activities who utilize respiratory protection and meet the requirements stipulated by 1910.120(f).

QUALITATIVE
RESPIRATOR FIT TEST WORKSHEET

Applicant Name ______________________

Organization ______________________

Date of Test ______________________

Employee Number ______________________

Equipment Type ______________________

Manufacturer ______________________

Model/Size ______________________

Test Conducted By ______________________

TEST RESULTS

(1)	Negative Pressure Test	Pass ( )	Fail ( ) _____
(2)	Positive Pressure Test	Pass ( )	Fail ( ) _____
(3)	Irritant Smoke Test Irritant Detected	Yes ( )	No ( ) _____

Employee briefed on fundamental principals of respiratory protection, use, inspection, cleaning, maintenance and storage of equipment. Yes ( ) No ( )

ADDITIONAL INFORMATION

Last Employee Physical Exam Conducted on ______________________

Stress Test Included Yes ( ) No ( )

At Medical Facility ______________________

Corrective Lenses Required for Normal Work Tasks Yes ( ) No ( )

Facial Characteristics: Clean Shaven ( ) Beard ( ) Other ( ) ______________ Specify

Follow-up Physical Due ______________________

I hereby certify the subject employee has been fit tested according to procedures specified in RESPIRATORY PROTECTION PROCEDURE NO. 3.

______________________ Tester's Name ____________ Date

Name:
Next test due:

TSI 8015 PORTACOUNT FIT-TESTING SOFTWARE
Version 2.01 S/N 1020
URIE ENVIRONMENTAL HEALTH, INC.

QUANITATIVE FIT TEST REPORT

Test Date: ______
Test Time: ______
Test Subject Last name: ______
Test Subject First Name: ______
ID Number: ______
Operator Name: ______
Next Fit Test Due: ______
Test Agent: ______
Test Device: ______

RESPIRATOR ID

Size: ______
Model: ______
Manufacturer: ______
Approval Number: ______

Additional Notes: ______
Additional Notes: ______

TEST DATA

Pass/Fail Level: ______
Test Cycles: ____

Ex.	Ambient (Part/cc)	Mask (Part/cc)	Fit Factor	Pass/Fail

OVERALL FIT FACTOR:______
(Calculated per ANSI Z88.2-1980)

Operator ______ Date ______

Test Subject ______ Date ______

STANDARD RESPIRATORY PROTECTION PROCEDURE NO. 1
RESPIRATORY PROTECTION PRINCIPLES

7.0 INTRODUCTION

Since the lungs are not completely effective in protecting the body against respirable chemical hazards, they must be artificially protected from toxic gases, vapors, and particulates. In addition, the body must be supplied with enough oxygen to maintain a normal capacity to perform tasks.

7.1 ROUTES OF EXPOSURE

The volume of air inhaled during "normal" activities is approximately 6 liters/min (l/m). The volume of air inhaled during brisk activity or during periods of stress can go up to 75 l/m (a 12-fold increase).

Air is inhaled through the nose and mouth and travels an extremely turbulent path to the lungs. This turbulency results in the air impinging on many sites, thus allowing the insoluble particulates to become impacted and soluble particulates, vapors, and gases to become absorbed.

The inhaled air passes through the pharynx, the common passageway for both food and air, and enters the trachea at the larynx. The trachea (or windpipe) divides into two bronchi, which lead to the two lungs. All of these organs are collectively called the conducting tubes, since they lead the air to the alveoli, the site of gaseous exchange with the pulmonary capillaries (i.e., the blood).

Toxic substances may be absorbed at any point in the respiratory tract. The conducting tubes are lined with mucus and cilia. Insoluble contaminants caught in the mucus are swept up to the esophagus by the cilia and swallowed, thus causing an ingestion problem.

7.2 OXYGEN DEFICIENCY

7.2.1 Oxygen and the Respiratory Process

The chemical composition of normal air is presented below as Table 1.

Table 1: Atmospheric Composition

Gas	Volume (%)	Partial Pressure (mm Hg at Sea Level)
Nitrogen	78.9	594
Oxygen	20.95	159
Argon	0.93	7
Carbon Dioxide	0.04	0.03

It is not the percentage of oxygen in the air, but rather its partial pressure, that is important in respiration. As one increases in altitude, the percentage of oxygen stays constant, but its partial pressure drops. Additionally, as the percentage of oxygen in the air drops, so does its partial pressure.

The "anatomic dead space volume" of the respiratory tract is about 150 milliliter (ml). The average breath draws in about 500 ml of air. This air is mixed with the air remaining in the dead space from the previous exhalation, which has been depleted in oxygen due to the normal respiratory process. The overall effect is a lower partial pressure of oxygen in the respiratory tract as compared with the ambient air. The average respirator adds about 100 ml of dead space to the respiratory system, which further lowers the partial pressure of oxygen in the respiratory system, causing a slight oxygen deficiency.

7.2.2 Oxygen Levels/Physiological Effect

The currently accepted National Institute for Occupational Safety and Health (NIOSH) standards specify that if an atmosphere contains less than 19.5 percent by volume oxygen at sea level, then an atmosphere-supplying device must be used.

Note that as altitude increases, the percentage of oxygen stays constant, but the partial pressure drops. There is currently no standard that accounts for the drop in partial pressure with altitude; the problem is currently under study by NIOSH.

The physiological effects of oxygen deficiency are indicated in Table 2.

7.3 PARTICULATE CONTAMINANTS - AEROSOLS

Aerosol is a term used to describe particulates in air without regard to their origin. Particulates are collected on the walls of the respiratory tract depending upon their size as follows:

1. Pharynx - 10-30 μm
2. Trachea - 10 μm
3. Bronchus - 5-10 μm
4. Alveoli - 0.1-1 μm

Particulates less than 0.5 μm may never be deposited in the respiratory tract and may simply be exhaled.

Particulates affect the human body as follows:

1. Nuisances - inert substances that cause no lung damage but inhibit proper functioning of the lungs.
2. Inert pulmonary reaction causing substances - substances that produce nonspecific pulmonary effects.
3. Pulmonary fibrosis causing substances - substances that produce effects ranging from nodule production to serious diseases such as asbestosis.
4. Irritants - substances that irritate, inflame, or ulcerate lung tissues.
5. Systemic poisons - substances that cause injury to specific organs and body systems.
6. Allergens - substances that produce hypersensitivity.

Table 2: Physiological Effects of Oxygen Deficiency

Oxygen Volume Percentage at Sea Level	Physiological Effect
16-12	Increased breathing volume. Accelerated heartbeat. Impaired attention and thinking. Impaired coordination.
14-10	Very faulty judgment. Very poor muscular coordination. Muscular exertion causes rapid fatigue that may cause permanent heart damage. Intermittent respiration.
10-6	Nausea. Vomiting. Inability to perform vigorous movement, or loss of all movement. Unconsciousness, followed by death.
Less than 6	Spasmatic breathing. Convulsive movements. Death in minutes.

7.4 GASEOUS CONTAMINANTS

Gaseous contaminants are "filtered" to a small degree by the respiratory tract before they reach the alveolar spaces. However, if the contaminants are soluble, they can be directly absorbed through the walls of the respiratory tract.

Gaseous contaminants affect the human body as follows:

● Irritants:	corrosive compounds that injure and inflame tissue.
● Asphyxiants:	substances that displace oxygen or prevent the use of oxygen by the body.
● Anesthetics:	substances that depress the central nervous system and cause intoxication or loss of sensation.
● Systemic poisons:	substances that cause diseases.

7.5 EXPRESSING AIR CONTAMINANT CONCENTRATIONS

Any substances that are not normal components of breathing air (i.e., oxygen, nitrogen, etc.) are considered to be contaminants. The respiratory threat posed by contaminants is a function of the actual contaminant and its concentration in the air. The concentration is expressed in a variety of ways, as listed below:

1. Particulates
   a. mppcf - millions of particulates per cubic foot.
   b. ppcc - particulates per cubic centimeter.
   c. mg/m^3 - milligrams per cubic meter.

2. Gases and Vapors
   a. ppm - volumes per million volumes of air (parts per million).
   b. ppb - volumes per billion volumes of air (parts per billion).
   c. mg/m^3 - milligrams of gas per cubic meter.
   d. Conversion of units. The following equation converts mg/m^3 to ppm, at 24oC and 760 mm Hg.

$$\text{ppm} = \frac{24.45}{\text{molecular weight}} \; mg/m^3$$

This equation is extremely useful for determining respiratory protection requirements.

7.6 MEASURES OF RESPIRATORY HAZARDS

Every contaminant contained in breathing air has a limit, above which it becomes a threat to human health. These limits are determined either from animal studies or from epidemiological data. Unfortunately, animal studies can only approximate human response and may vary widely for individual chemicals. Epidemiological studies, although capable of providing a more precise forecast of human response, are limited by a lack of accurate records and a lack of controlled studies. Therefore, the "safe" limits of various chemicals must be viewed only as guidelines. Furthermore, these guidelines are primarily designed for the industrial situation where an individual is being exposed to one or two well-defined substances. These guidelines do not address the problems of synergism, potentiation, or allergic response.

The guidelines used in measuring respiratory hazards are listed below:

1. **Threshold Limit Value** - The threshold limit value (TLV) is recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) and is derived from consensus review. It is a time-weighted average concentration set for a particular substance that represents a level that almost all workers can be exposed to for an 8-hour day (40-hour week) without suffering adverse health effects. It is assumed that following each 8-hour exposure there will be a 16-hour recovery period and that after 5 days there will be a 48-hour recovery period. The TLV lists are revised on a yearly basis.

2. **Permissible Exposure Limits** - The permissible exposure limits (PELs) are set forth in the Occupational Safety and Health Administration (OSHA) Standards 29 CFR 1910.1000, Tables Z-2, Z-2, and Z-3. These levels were promulgated initially from the ACGIH TLV lists (1968). As part of the law, they represent the legal maximum concentrations for personnel exposure. They are not updated on a yearly basis, as is the TLV list. Therefore, the most current ACGIH TLV is used in determining respiratory protection, rather than the PEL listing.

3. **Immediately Dangerous to Life and Health** - 30 CFR 11.3 defines conditions that are immediately dangerous to life and health (IDLH) as "conditions that pose an immediate threat to life or health or conditions that pose an immediate threat of severe exposure to contaminants such as radioactive materials, which are likely to have an adverse cumulative or delayed effect on health".

   OSHA adds these criteria:

   a. The worker must be able to escape without losing his life or suffering permanent health damage within 30 minutes.

   b. The worker must be able to escape without severe eye or respiratory irritation or other reactions.

4. **Lower Flammable Limit** - The lower flammable limit (LFL) is the lowest concentration by volume of a gas or vapor in air that will explode when there is an ignition source.

7.7 RESPIRATORY PROTECTION

When it has been determined that the ambient atmosphere is hazardous, it becomes necessary to protect the individual by:

1. avoiding and/or minimizing exposure;
2. applying engineering controls such as ventilation; and
3. using a respirator to either filter the air or supply air.

The legal requirements for respiratory protection are summarized below:

1. Williams and Steiger Occupational Safety and Health Act of 1970 established standards which state that "approved or accepted respirators shall be used when they are available".

2. 29 CFR 1910.134 give legal requirements for the selection and use of respiratory equipment as promulgated by OSHA and based on American National Standards Institute (ANSI) Standard Z88.2, "American National Standards Practice for Respiratory Protection". Standard Z88.2 was originally a consensus standard, but now has been cited as a Federal regulation.

3. 30 CFR Part 11 describes tests for permissibility of respiratory protective apparatus and updates or deletes approvals. 30 CFR Part 11 also cites ANSI Z88.2 as the basis for respiratory protection.

STANDARD RESPIRATORY PROTECTION PROCEDURE NO. 2
SELECTION OF RESPIRATORS

8.0 INTRODUCTION

This text is based on "Joint NIOSH/OSHA Standards Complete Program - Respirator Decision Logic". The text is excerpted for the purpose of covering the major points of the respirator decision logic. For the complete text, see John S. Pritchard's, "A Guide to Industrial Respiratory Protection" (U.S. Department of Health, Education and Welfare, U.S. Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, Ohio, June 1976). It is not intended to be all-inclusive in content.

The purpose of the respirator decision logic is to provide technical accuracy and uniformity in the selection of respirators and to provide necessary criteria to support this selection. The decision logic is a step-by-step elimination of inappropriate respirators until only those that are acceptable remain. Judgment by persons knowledgeable of inhalation hazards and respiratory protection equipment is essential to ensure appropriate selection of respirators.

The primary technical criteria for what constitutes a permissible respirator are based on the technical requirements of 30 CFR 11. The health standards will allow only respirators approved under 30 CFR 11. Classes of respirators are only included when at least one device has been approved.

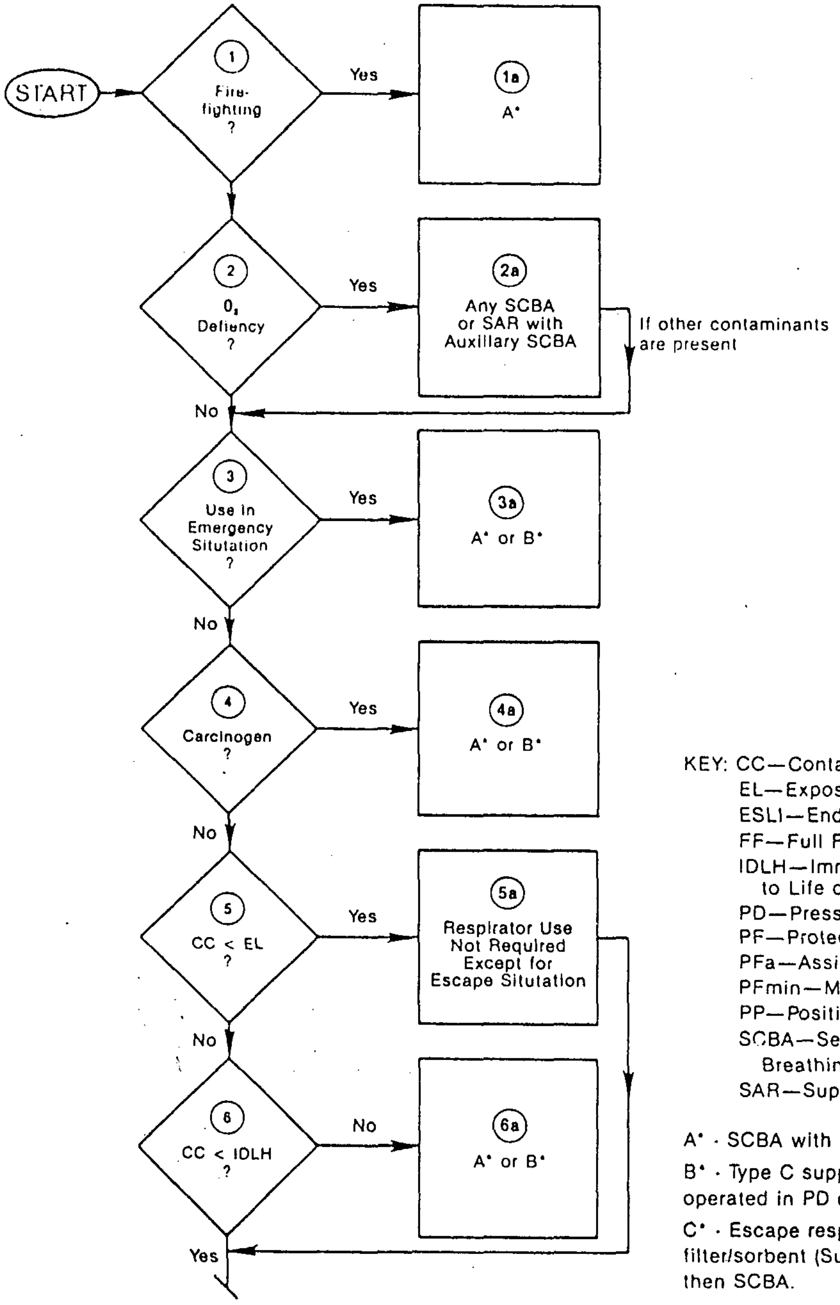
Protection factors are criteria used in determining what limiting concentrations are to be permitted for each respirator type that will afford adequate protection to the wearer. The referenced Subparts of 30 CFR 11 give technical descriptions concerning each type or class of respirators referenced in the decision logic; 30 CFR 11 should be used with the decision logic in order to properly understand the criteria for the specification of allowable respirators.

Throughout this text, reference is made to PELs. Prudent, accepted practice dictates the use of current ACGIH TLVs, which are updated each year, in the place of the PEL, which is only periodically updated.

8.1 GENERAL DECISION LOGIC FLOWCHART

The following material used in concert with the decision logic chart (Figure 1) provides a formalized selection guide for respiratory protection.

1. **Step 1: Assembly Information on Substance** - Assemble necessary toxicological, safety, and research information for the particular contaminant. The following are required:
    a. Permissible exposure limits specified in 29 CFR 1910.1000 (Tables Z-1, Z-2, and Z-3).
    b. Warning properties if the substance is a gas or a vapor.
    c. Eye irritation potential of the substance.
    d. LFL for the substance.
    e. IDLH concentration for the substance.
    f. Any possibility of poor sorbent efficiency at IDLH concentration and below.
    g. Any possibility of systemic injury or death resulting from absorbance of the substance (as a gas or vapor) through the skin.
    h. Any possibility of severe skin irritation resulting from contact of the skin with corrosive gases, vapors, or particulates.
    i. The vapor pressure of the substance (and equivalent ppm).
    j. Any possibility of high heat of reaction with sorbent material in cartridge or canister.



KEY: CC—Contaminant Concentration
EL—Exposure Limit
ESLI—End of Service Life Indicator
FF—Full Facepiece
IDLH—Immediately Dangerous to Life or Health
PD—Pressure Demand
PF—Protection Factor
PFa—Assigned PF
PFmin—Minimum PF
PP—Positive Pressure
SCBA—Self-Contained Breathing Apparatus
SAR—Supplied-Air Respirator

A* · SCBA with FF operated in PD or PP mode.

B* · Type C supplied-air respirator (airline) operated in PD or PP mode with auxiliary SCBA.

C* · Escape respirator or gas mask with appropriate filter/sorbent (Subparagraph 5); if O_2 deficient, then SCBA.

Figure 1. — Flow Chart of Respirator Decision Logic Sequence

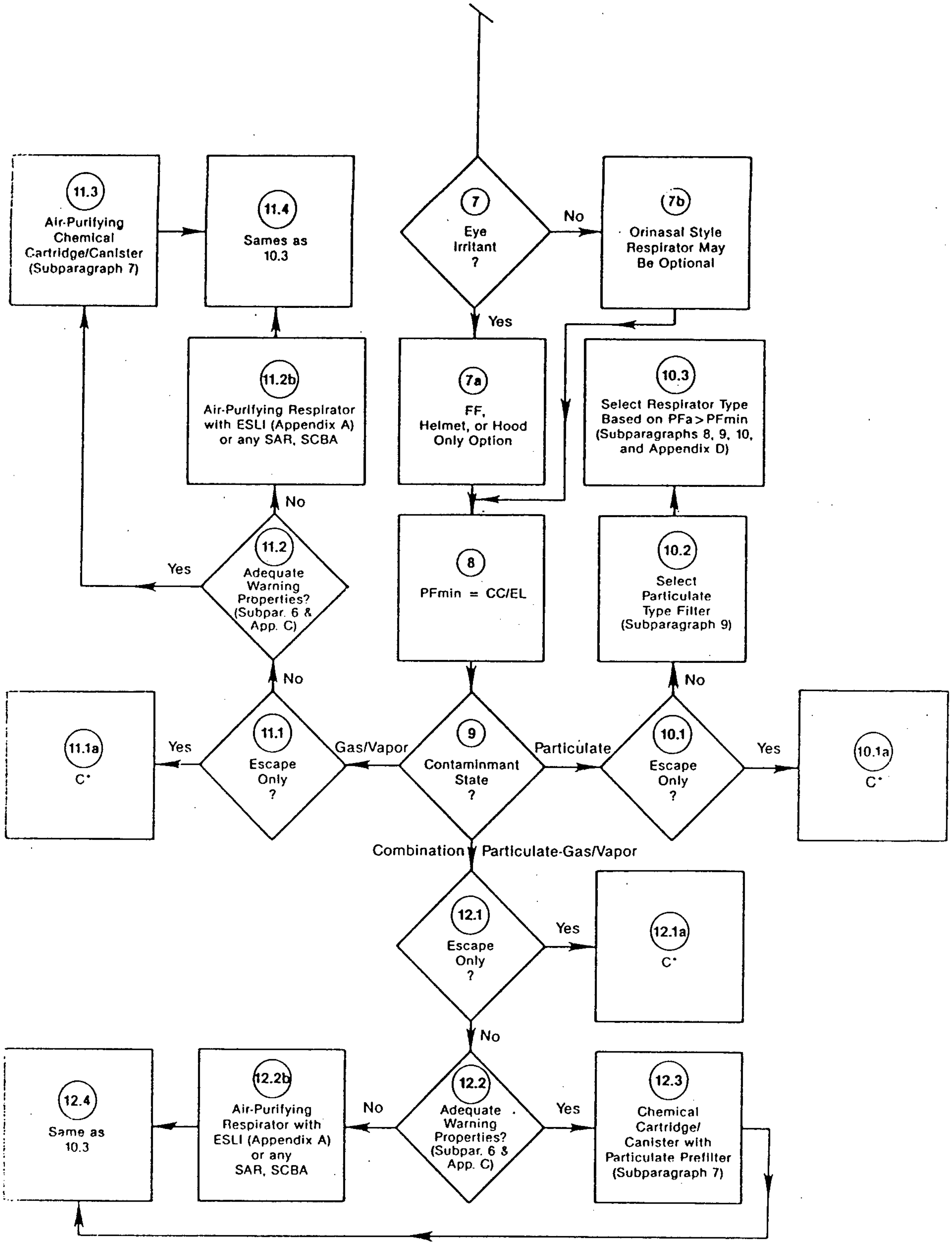


Figure 1. — Flow Chart of Respirator Decision Logic Sequence — Continued

2. **Step 2: Determine Physical State of Substance** - Determine the physical state(s) of the substance as it is likely to be encountered in the occupational environment. It will be either (1) gas or vapor; (2) particulate (dust, fume or mist); or (3) combination of (1) and (2).

3. **Step 3: Assemble a Table of Permissible Respiratory Protection for Substance** - This is done using the material from Step 1 and the appropriate specific decision logic chart from Section 8.2 below and respirator protection factors. Classes of respirators are only included where at least one device has been approved.

4. IF STEPS 1 THROUGH 3 CANNOT BE COMPLETED, THE ATMOSPHERE IS UNKNOWN AND MUST BE CLASSIFIED IDLH. ONLY POSITIVE PRESSURE SCBA MAY BE SELECTED.

8.2 SPECIFIC DECISION LOGIC CHARTS

A decision logic chart for respiratory protection against gases or vapors and against particulates is shown as Figure 1.

8.3 DECISION LOGIC CRITERIA

8.3.1 Skin Absorption and Irritation

Respirator selection criteria are based primarily on the inhalation hazard of the substance. A supplied-air suit may protect the skin from extremely toxic substances that may be absorbed through the skin or from substances which may cause severe skin irritation or injury.

Supplied-air suits are not covered in 30 CFR 11. Data are not available upon which to make recommendations for supplied-air suits for all types of exposures.

Where information is available indicating systemic injury or death resulting from absorbance of gas or vapor through the skin or severe skin irritation or injury may occur from exposure to a gas, corrosive vapor, or particulate, the following statement is included as a footnote to the respirator tables, and both the employee and employer are cautioned in the appendices concerning their use:

> Use of supplied-air suit may be necessary to prevent skin contact and respiratory exposure from airborne concentrations of (specific substance). Supplied-air suits should be selected, used, and maintained under the immediate supervision of persons knowledgeable in the limitations and potential life-endangering characteristics of supplied-air suites. Where supplied-air suits are used above a concentration which may be IDLH (concentration), an auxiliary positive-pressure self- contained breathing apparatus must also be worn.

As a guideline for inclusion of the supplied air-suit statement for substances that are sorbed through the skin, a single skin penetration LD_{50} of 2 g/kg for any species is used.

8.3.2 Poor Warning Properties (Refer to Table 1)

It is important to realize that 30 CFR 11 approvals for air-purifying (organic vapor) devices prohibit use against organic vapors with poor warning properties.

Warning properties include odor, eye irritation, and respiratory irritation. Warning properties relying upon human senses are not foolproof. However, they provide some indication to the wearer of possible sorbent exhaustion or of poor facepiece fit or other respirator malfunction.

Adequate warning properties can be assumed when the substance odor, taste, or irritation effects are detectable and persistent at concentrations at or below the PEL.

If the odor or irritation threshold of a substance is more than three times greater than the permissible exposure limit, this substance should be considered to have poor warning properties. If the substance odor or irritation threshold is somewhat above the permissible exposure limit (not in excess of three times the limit) and there is no ceiling limit, consideration is given to whether undetected exposure in this concentration range could cause serious or irreversible health effects. If not, the substance is considered to have adequate warning properties. Some substances have extremely low thresholds of odor and irritation in relation to the permissible exposure limit. Because of this, these substances can be detected by a worker within the facepiece of the respirator even when the respirator is functioning properly. These substances are, therefore, considered to have poor warning properties.

Though 30 CFR 11 does not specifically eliminate air-purifying respirators for pesticides with poor warning properties, prudent practice dictates that a respirator should not be used to protect against any substance with poor warning properties.

Table 3. EFFECT OF SOLVENT VAPOR ON RESPIRATOR CARTRIDGE EFFICIENCY[a]

Solvent	Time to Reach 1 Percent Breakthrough (10 ppm) (Min)
Aromatics	
Benzene	73
Toluene	94
Ethyl benzene	84
m-Xylene	99
Cumene	81
Mesitylene	86
Alcohols	
Methanol	0.2
Ethanol	28
Isopropanol	54
Allyl alcohol	66
n-Propanol	70
Sec-Butanol	96
Butanol	115
2-Methoxyethanol	116
Isoamyl alcohol	97
4-Methyl-2-pentanol	75
2-Ethoxyethanol	77
Amyl Alcohol	102
2-Ethyl-1-butanol	76.5
Monochlorides	
Methyl chloride	0.05
Vinyl chloride	3.8
Ethyl chloride	5.6
Allyl chloride	31
1-Chloropropane	25
1-Chlorobutane	72
Chlorocyclopentane	78
Chlorobenzene	107
1-Chlorohexane	77
o-Chlorotoluene	102
1-Chloroheptane	82
3-Chloromethyl heptane	63
Dichlorides	
Dichloromethane	10
Trans-1,2-dichloroethylene	33
1,1-Dichloroethane	23
cis-1,2-Dichloroethylene	30
1,2-Dichloroethane	54
1,2-Dichloropropane	65
1,4-Dichlorobutane	108
o-Dichlorobenzene	109

Trichlorides	
Chloroform	33
Methyl chloroform	40
Trichloroethylene	55
1,1,2-Trichloroethane	72
1,2,3-Trichloropropane	111
Tetra- and Pentachlorides	
Carbon tetrachloride	77
Perchloroethylene	107
1,1,2,2-Tetrachloroethane	104
Pentachloroethane	93
Acetates	
Methyl acetate	33
Vinyl acetate	55
Ethyl acetate	67
Isopropyl acetate	65
Isopropenyl acetate	83
Propyl acetate	79
Allyl acetate	76
sec-Butyl acetate	83
Butyl acetate	77
Isopentyl acetate	71
2-Methoxyethyl acetate	93
1,3-Dimethylbutyl acetate	61
Amyl acetate	73
2-Ethoxylethyl acetate	80
Hexyl acetate	67
Ketones	
Acetone	37
2-Butanone	82
2-Pentanone	104
3-Pentanone	94
4-Methyl-2-pentanone	96
Mesityl oxide	122
Cyclopentanone	141
2-Heptanone	91
3-Heptanone	101
Cyclohexanone	126
5-Methyl-3-heptanone	86
3-Methylcyclohexanone	101
Diisobutyl ketone	71
4-Methylcyclohexanone	111
Alkanes	
Pentane	61
Hexane	52
Methylcyclopentane	62
Cyclohexane	69
Cyclohexene	86
2,2,4-Trimethylpentane	68
Heptane	78
Methycychlohexane	69
5-Ethylidene-2-norbornene	87
Nonane	76
Decane	71

Amines	
Methyl amine	12
Ethyl amine	40
Isopropyl amine	66
Propyl amine	90
Diethyl amine	88
Butyl amine	110
Triethyl amine	81
Dipropyl amine	93
Diisopropyl amine	77
Cyclohexyl amine	112
Dibutyl amine	76
Miscellaneous Materials	
Acrylonitrile	49
Pyridine	119
1-Nitropropane	143
Methyl iodide	12
Dibromomethane	82
1,2-Dibromoethane	141
Acetic anhydride	124
Bromobenzene	142

---

[a] The above cartridge pairs were tested at 1000 ppm, 50 percent relative humidity, 22oC, and 53.3 liters/min. (equivalent to a moderately heavy work rate). The time to achieve a 1 percent breakthrough is noted for each cartridge pair. Cartridges were preconditioned at room temperature and 50 percent relative humidity for at least 24 hours prior to testing.

> "Immediately dangerous to life of health" means conditions that pose an immediate threat to life or health or conditions that pose and immediate threat of severe exposure to contaminants, such as radioactive materials, which are likely to have adverse cumulative or delayed effects on health".

The purpose of establishing an IDLH exposure concentration is to ensure that the worker can escape without injury or irreversible health effects from an IDLH concentration in the event of failure of the respiratory protective equipment. The IDLH is considered a maximum concentration above which only highly reliable breathing apparatus providing maximum worker protection is permitted. Since IDLH values are conservatively set, any approved respirator may be used up to its maximum use concentration below are IDLH.

The establishing the IDLH concentration the following factors are considered:

1. Escape without loss of life or irreversible health effects. Thirty minutes is considered the maximum permissible exposure time for escape.

2. Severe eye or respiratory irritation or other reactions that would prevent escape without injury.

IDLH should be determined from the following sources:

1. Specific IDLH provided in the literature, such as the AIHA Hygienic Guides.
2. Human exposure data.
3. Acute animal exposure data.

Where such data are lacking, acute toxicological data from analogous substances may be considered.

The following guidelines should be used to interpret toxicological data reported in the literature for animal species:

1. Where acute animal exposure data are available (30 min. to 4-hour exposures), the lowest exposure concentration causing death or irreversible health effects in any species is determined to be the IDLH concentration.
2. Chronic exposure data may have no relevance to the acute effects and should be used in determining the IDLH concentration only upon competent toxicologic judgment.
3. Where there is no toxicologic evidence of an IDLH concentration, 500 times the permissible exposure limit shall determine the upper limit above which only highly reliable breathing apparatus providing maximum worker protection is used.

8.3.3 Lower Flammable Limit

In addition to toxic chemicals and irritants, it is necessary to consider flammable substances. In any atmosphere where there is a likelihood of a chemical fire, there is the risk of creating toxic vapors in the fire or of asphyxiation caused by reduction of the oxygen content by the products of combustion.

Contaminant concentrations in excess of the LFL are considered to be IDLH. At or above the LFL, the use of respirators is limited to those devices that provide the maximum protection (i.e., positive pressure self-contained breathing apparatus (SCBA) and the combination positive pressure supplied-air respirators with auxiliary positive pressure SCBA).

8.3.4 Protection Factors

The protection factors of respiratory protection devices are a useful numerical tool to assist in the choice of a protective system. Protection factors are a measure of the overall effectiveness of a respirator. Filtering efficiency is a part of the protection factor and becomes significant consideration for less efficient air-purifying respirators.

The protection factor of a given respirator for a specific user times the PEL (or TLV) for a given substance is the maximum allowable concentration for that substance for which the respirator may be used. For example, say the protection factor for a full-face mask respirator will provide protection up to 1000 ppm. Note that there is a difference between "quantitative" protection factors and "qualitative" protection factors. The correct protection factor must be used in determining the maximum allowable concentration.

8.3.5 Escape

Site personnel will carry an escape respirator where exposure to extremely toxic substances may occur. This escape respirator provides a 5-minute self-contained air supply. (An extremely toxic substance is defined as a gas or vapor having an LC_{50} of less than 10 ppm).

9.0 RESPIRATOR QUALITATIVE FITTING METHODS

Despite the care that goes into respirator design and manufacture to give maximum protection, efficiency will be lost if there is an improper match between the facepiece and the user, or other improper wearing practices. The problem is twofold. Since more than one brand of a particular type of facepiece is available, the first problem is to determine which fits best. The second problem is whether the user knows when the respirator fits properly. Both problems can be solved by the use of a fitting test, which is in fact an OSHA requirement. A number of tests and fitting procedures can be performed easily, as outlined below.

Note: During any fitting test, the respirator head straps must be as comfortable as possible. Tightening the straps will sometimes reduce the facepiece leakage, but the user may be unable to tolerate the respirator for any length of time.

9.0.1 Test 1 - Negative Pressure Test

The user will perform this test alone in the field. It consists of merely closing off the inlets of the canister, cartridge(s), or filter(s) by covering with the palm(s) or replacing the seals over the canister or cartridge inlets, or by squeezing breathing tubes so that air cannot pass; inhaling gently so the facepiece collapses slightly; and holding the breath for ten seconds. If the facepiece remains slightly collapsed and no inward leakage is detected, the respirator is probably tight enough.

Although this test is simple, it has several major drawbacks, primarily that the user must handle the respirator after it has supposedly been positioned on the face. Handling can modify the facepiece-to-face seal. When the respirator is to be used in a relatively toxic atmosphere, this test should be used only as a very gross determination of fit. The user will perform this test just before entering any toxic atmosphere.

9.0.2 Test 2 - Positive Pressure Test

This test is very much like the negative pressure test; it has the same advantages and limitations. It is conducted by closing off the exhalation valve and exhaling gently into the facepiece. The fit is considered satisfactory if slight positive pressure can be built up inside the facepiece without any evidence of outward leakage. For some respirators, this method requires the user to remove the exhalation valve cover and then carefully replace it after the test, often a most difficult task which can disturb the respirator fit even more than does the negative pressure test. If removing and replacing the valve cover is required, this test should be used sparingly. For respirators whose valve covers have a single small port that can be covered by the palm or finger, this test is easy. Where applicable, this test will be performed just before entering any hazardous atmosphere.

9.0.3 Test 3 - Irritant Smoke Test

This test is similar to the isoamyl acetate test in concept. It involves exposing the respirator wearer to an irritating aerosol produced by stannic chloride or titanium tetrachloride smoke tubes normally used to check the quality of ventilation systems (Note: Other types of smoke tubes such as acetic acid are available, but should not be used for respirator fitting). When the tube ends are broken and air is passed through it, the material inside reacts with the moisture in the air to produce a dense, highly irritating smoke, consisting of hydrochloric acid absorbed in small solid particles. As a qualitative means of determining respirator fit, this test has a distinct advantage in that the user usually reacts involuntarily to leakage by coughing or sneezing. The likelihood of this giving a false indication of proper fit is reduced. On the other hand, the aerosol is very irritating and must be used carefully to avoid injury.

This test can be used for both air-purifying and atmosphere-supplying respirators, but air-purifying respirators must have a high-efficiency filter(s). After the test, it may be necessary to replace the high-efficiency filter(s) on the air-purifying respirator with another type of air-purifying element(s) depending upon the hazard to which the respirator user is to be exposed. This test can be used for worker training or respirator selection.

The irritant smoke test must be performed with proper safeguards because the aerosol is highly irritating. The procedure is as follows:

1. The user puts on the respirator normally, taking care not to tighten care not to tighten the head strap uncomfortably and stands with his/her back to a source of exhaust ventilation.

2. The tester tells the user to close his/her eyes, even if wearing a full facepiece respirator, and to keep them closed until told to open them.

3. The tester lightly puffs smoke over the respirator, holding the smoke tube at least two feet from it. At this time, the test should keep the amount of smoke minimal and pause between puffs to note the user's reaction.

4. If the user detects no leakage, the tester will increase the smoke density and move the smoke tube progressively closer to the subject, still remaining alert to any reactions.

5. When the smoke tube has been brought to within about 6 inches of the respirator with no leakage detected, the tester will start to direct smoke specifically at potential sources of leakage, around the sealing surfaces and exhalation valve, while the subject's head is still.

6. At this point, if no leakage has been detected, the user may cautiously begin the head movements described in the isoamyl acetate test. The tester should remain especially alert and be prepared to stop producing smoke immediately.

7. If leakage is detected at any time, the tester should stop the smoke and let the user readjust the facepiece or head strap tension. The tester should then start the test at step 2.

9.0.4 Test 4 - Quantitative Respirator Fit Test

STANDARD RESPIRATORY PROTECTION PROCEDURE NO. 4
INSPECTION/MAINTENANCE/STORAGE

10.0 INTRODUCTION

Respirator maintenance is an integral part of the overall respirator program. Wearing a poorly maintained or malfunctioning respirator is, in one sense, more dangerous that not wearing a respirator at all. Personnel wearing defective devices think they are protected when, in reality, they are not. Emergency escape and rescue devices are particularly vulnerable to poor maintenance as they generally are used infrequently, and then in the most hazardous and demanding circumstances. Serious injury or death can result from wearing a defective device during emergency escape or rescue.

This program includes:

1. Inspection for defects (including a leak check).
2. Cleaning and disinfecting.
3. Repair as required.
4. Proper and sanitary storage of equipment.

10.1 INSPECTION FOR DEFECTS

The most important part of a respirator maintenance program is continual inspection of the devices. If properly performed, inspections will identify damaged or malfunctioning respirators before they can be used. Two types of inspections will be performed.

1. While the respirator is in use.
2. While it is being cleaned.

Since the use and cleaning will, to a large extent, be performed by the same personnel, these inspections may become concurrent.

10.2 FREQUENCY OF INSPECTION

OSHA requires that "All respirators be inspected before and after each use" and that those not used routinely, i.e., emergency escape and rescue devices, "shall be inspected after each use and at least monthly..." Obviously, emergency escape and rescue devices do not require inspection before each use. Records of inspections are kept on forms presented in Section VI-Program Administration and Documentation.

10.3 INSPECTION PROCEDURES

Respirator inspection shall include checking of:

1. Tightness of the connections.
2. Facepiece.
3. Valves.
4. Connecting tubes.
5. Canisters, filters, or cartridges.

In addition, the regulator and warning devices on a SCBA shall be checked for proper functions.

10.4 FIELD INSPECTION OF AIR-PURIFYING RESPIRATORS

Routinely used air-purifying respirators will be checked as follows before and after each use:

1. Examine the facepiece for:
    a. Excessive dirt.
    b. Cracks, tears, holes or physical distortion of shape from improper storage.
    c. Inflexibility of rubber facepiece (stretch and knead to restore flexibility).
    d. Cracked or badly scratched lenses in full facepieces.
    e. Incorrectly mounted full facepiece lenses, or broken or missing mounting clips.
    f. Cracked or broken air-purifying element holder(s), badly worn threads or missing gasket(s).
2. Examine the head straps or head harness for:
    a. Breaks.
    b. Loss of elasticity.
    c. Broken or malfunctioning buckles and attachments.
    d. Excessively worn serrations on head harness, which might permit slippage (full facepieces only).
3. Examine the exhalation valve for the following after removing its cover:
    a. Foreign material, such as detergent residue, dust particles or human hair under valve seat.
    b. Cracks, tears or distortion in the valve material.
    c. Improper insertion of the valve body, particularly the sealing surface.
    d. Cracks, breaks or chips in the valve body, particularly the sealing surface.
    e. Missing or defective valve cover.
    f. Improper installation of the valve in the valve body.
4. Examine the air-purifying element(s) for:
    a. Incorrect cartridge, canister or filter for the hazard.
    b. Incorrect installation, loose connections, missing or worn gasket or cross threading in the holder.
    c. Expired shelf-life date on the cartridge or canister.
    d. Cracks or dents in the outside case of the filter, cartridge or canister, indicated by the absence of sealing material, tape, foil, etc. over the inlet.
    e. Identical cartridges if more than one are used.

10.5 CARE AND CLEANING OF SELF-CONTAINED BREATHING APPARATUS (SCBA)

The proper care of SCBAs involves:

1. Inspection for defects.
2. Cleaning and disinfecting.
3. Repair
4. Storage

The following checklist is to be used by personnel whenever they have to check out an SCBA. (Note: Any discrepancy found should be cause to set the unit aside until it can be repaired by a certified repair-person.)

1. Preliminary inspection. Check to ensure that:
    a. High-pressure hose connector is tight on cylinder fitting.
    b. Bypass valve is closed.
    c. Mainline valve is closed.
    d. There is no cover or obstruction on regulator outlet.
    e. Pressure in the tank is at least 1800 psi.

2. Backpack and harness assembly.

    a. Straps.
        1. Visually inspect for complete set.
        2. Visually inspect for frayed or damaged straps that may break during use.

    b. Buckles.
        1. Visually inspect for mating ends.
        2. Check locking function.

    c. Backplate and cylinder lock.
        1. Visually inspect backplate for cracks and for missing rivets or screws.
        2. Visually inspect cylinder hold-down strap and physically check strap tightener and lock to ensure that it is fully engaged.

3. Cylinder and cylinder valve assembly.

    a. Cylinder.
        1. Physically check cylinder to ensure that it is tightly fastened to backplate.
        2. Check hydrostatic test date to ensure that it is current.[1]
        3. Visually inspect cylinder for large dents or gouges in metal.

    b. Head and valve assembly.
        1. Visually inspect cylinder valve lock for presence.
        2. Visually inspect cylinder gauge for condition of face, needle, and lens.
        3. Open cylinder valve and listen or feel for leakage around packing. (If leaking is noted, do not use until repaired.) Note function of valve lock.

4. Regulator and high-pressure hose.

    a. High-pressure hose and connector.

        Listen or feel for leakage in hose or at hose-to-cylinder connector (Bubble in outer hose covering may be caused by seepage of air through hose when stored under pressure. This does not necessarily mean a faulty hose.)

    b. Regulator and low-pressure alarm.
        1. Cover outlet of regulator with palm of hand. Open mainline valve and read regulator gauge (must read at least 1800 psi and not more than rated cylinder pressure).

---

[1] Monthly inspection only.

2. Close cylinder valve and slowly move hand from regulator outlet to allow slow flow of air. Gauge should begin to show immediate loss of pressure as air flows. Low-pressure alarm should sound between 650 and 550 psi. Remove hand completely from outlet and close mainline valve.
3. Place mouth onto or over regulator outlet and blow. A positive pressure should be created and maintained for 5 to 10 seconds without any loss of air. Next, establish a slight negative pressure in regulator and hold for 5 to 10 seconds. Vacuum should remain constant. This tests the integrity of the diaphragm. Any loss of pressure or vacuum during this test indicates a leak in the apparatus.
4. Open cylinder valve.
5. Place hand over regulator outlet and open mainline valve. Remove hand from outlet and replace in rapid movement. Repeat twice. Air should escape when hand is remove each time, indicating a positive pressure in chamber. Close mainline valve and remove hand from outlet.
6. Ascertain that no obstruction is in or over the regulator outlet. Open and close the bypass valve momentarily to ensure flow of air through bypass system.

5. Facepiece and corrugated breathing tube.

    a. Facepiece.
        1. Visually inspect head harness for damaged serrations and deteriorated rubber. Visually inspect rubber facepiece body for signs of deterioration or extreme distortion.
        2. Visually inspect lens for proper seal in rubber facepiece, retaining clamp properly in place, and cracks or large scratches.
        3. Visually inspect exhalation valve for visible deterioration or foreign materials buildup.

    b. Breathing tube and connector.
        1. Stretch breathing tube and visually inspect for deterioration and holes.
        2. Visually inspect connector to ensure good condition of threads and for presence and proper condition of "O" ring or rubber gasket seal.
        3. Negative pressure test on facepiece.[2]
            (a) Don backpack and facepiece.
            (b) With facepiece held tightly to face or facepiece properly donned, stretch breathing tube to open corrugations and place thumb or hand over end of connector.
            (c) Inhale. Negative pressure should be created inside mask, causing it to pull tightly to face. This negative pressure should be maintained for 5 to 10 seconds. If negative pressure leaks down, the facepiece assembly is not adequate and should not be worn.

6. Storage of units. Check that:

    a. Cylinder is refilled as necessary and unit is cleaned and inspected.
    b. Cylinder valve is closed.
    c. High-pressure hose connector is tight on cylinder.
    d. Pressure is bled off high-pressure hose and regulator.

---

[2] For regular monthly inspection, only steps (b) and (c) of procedure are necessary.

e. Bypass valve is closed.
f. Mainline valve is closed.
g. All straps are completely loosened and laid straight.
h. Facepiece is properly stored to protect against dust, sunlight, heat, extreme cold, excess moisture, and damaging chemicals.

10.6 CLEANING AND SANITIZING

Any good detergent may be used followed by a disinfecting rinse or a combination disinfectant-detergent for a one step operation. Reliable, effective disinfectants may be made from readily available household solutions, including:

1. Hypochlorite solution (50 ppm or chlorine) made by adding approximately 0.8 milliliters of bleach (such as Clorox) to one liter of water, or two tablespoons of bleach per gallon of water. A two-minute immersion disinfects the respirators.

2. Aqueous solution of iodine (50 ppm of iodine) made by adding approximately 0.8 milliliters of tincture of iodine per liter of water, or one teaspoon of tincture of iodine per gallon of water. Again, a two-minute immersion is sufficient.

To prevent damaging the rubber and plastic in the respirator facepieces, the cleaning water should not exceed 140°F, but it should not be less than 120°F to ensure adequate cleaning.

10.7 RINSING

The cleaned and disinfected respirators should be rinsed thoroughly in water 140°F (maximum) to remove all traces of detergent and disinfectant. This is very important for preventing dermatitis.

10.8 DRYING

The respirators may be allowed to dry in room air on a cleaning surface. They may also be hung from a horizontal wire, like drying clothes, but care must be taken not to damage or distort the facepieces.

10.9 REASSEMBLY AND INSPECTION

The clean, dry respirator facepieces should be reassembled and inspected in an area separate from the disassembly area to avoid contamination. The inspection procedures have been discussed; special emphasis should be given to inspecting the respirator for detergent or soap residue left by inadequate rinsing. This appears most often under the seat of the exhalation valve, and can cause valve leakage or sticking.

The respirator should be thoroughly inspected and all defects corrected. New or retested cartridges and canisters should be installed, and the completely reassembled respirator should be tested for leaks.

For SCBA devices, the facepiece should be combined with the tested regulator and the fully charged cylinder, and an operational check performed.

10.10 RESPIRATOR STORAGE

Respirators must be stored to protect against:

1. Dust.
2. Sunlight.
3. Heat.
4. Extreme cold.
5. Excessive moisture.
6. Damaging chemicals.
7. Mechanical damage.

Damage and contamination or respirators may take place if they are stored on a workbench, or in a tool cabinet or toolbox, among heavy tools, greases and dirt or in a vehicle.

Freshly cleaned respirators should be placed in reusable plastic bags until reused. They should be stored in a clean, dry location away from direct sunlight. They should be placed in a single layer with the facepiece and exhalation valve in an undistorted position to prevent rubber or plastic from taking a permanent distorted "set".

APPENDIX H

HAZARD COMMUNICATION PROGRAM

SITE HAZARD COMMUNICATION PROGRAM

1.0 Purpose and Scope

The purpose of this program is to establish compliance with the OSHA Hazard Communication Standard, Title 29 Code of Federal Regulations 1910.1200, by: compiling a hazardous chemicals list; providing Material Safety Data Sheets (MSDS); ensuring that containers are labeled; providing training; and establishing communication of the required information to outside contractors.

This program applies to all operations where the potential for exposure to hazardous substances exists under normal working conditions or during an emergency situation.

2.0 Responsibilities

The SSO, Joan Henehan (or alternate), is the program coordinator, acting as the representative of the Project Manager, who has overall responsibility for the program. The SSO will review and update the program, as necessary.

The SSO will develop a list of all the hazardous materials and related work practices used on-site, and will update the list as necessary. This list of chemicals will include all those chemicals used by the field staff and subcontractors during the Remedial Investigation. A master list of these chemicals will be maintained by, and is available from the SSO.

3.0 Material Safety Data Sheets (MSDS's)

MSDS's provide specific information on the chemicals used by the field staff. The SSO will maintain a binder in his/her office with an MSDS on every substance on the hazardous chemicals list. The MSDS will be a fully completed OSHA Form 174 or equivalent. The Project Manager will ensure that each work site maintains an MSDS for hazardous materials in that area. MSDS's will be available at all times during work shifts.

The SSO is responsible for acquiring and updating MSDS's. He/she will contact the chemical manufacturer or vendor if additional research is necessary or if an MSDS has not been supplied. All new procurements must be cleared by the SSO.

4.0 Labels and Other Forms of Warning

The SSO will ensure that all hazardous materials on-site are properly labeled and updated, as necessary. Labels should list the chemical identity, appropriate hazard warnings, and the name of the manufacturer, importer or other responsible party. The SSO will refer to the corresponding MSDS to assist in verifying label information. Containers that are imported/exported on-site will be checked by the SSO to insure that all containers are properly labeled.

5.0 Training

Everyone who works with or is potentially exposed to hazardous chemicals will receive initial training on the Hazard Communication Standard and the safe work procedures of those hazardous chemicals by the SSO. Regular safety meetings will also be used to review the information presented in the initial training and to provide information on new hazardous materials. Foremen and other supervisors will be extensively trained regarding hazards and appropriate protective measures so they will be available to answer questions from employees and provide daily monitoring of safe work practices.

The training plan will emphasize these items:

- Summary of the standard and this written program.
- Chemical and physical properties of hazardous materials (e.g., flash point, reactivity) and methods that can be used to detect the presence or release of chemicals.
- Health hazards, including signs and symptoms of exposure, associated with exposure to chemicals and any medical conditions known to be aggravated by exposure to the chemical.
- Procedures to protect against hazards (e.g., personal protective equipment required, safe work practices/methods to assure proper use and handling; and procedures for emergency response).
- Where MSDS's are located, how to interpret the information on both labels and MSDS's, and how employees may obtain additional hazard information.

The SSO will review the employee training program and advise the project manager on training or retraining needs. Retraining is required when the hazard changes or when a new hazard is introduced. The SSO will evaluate the training program and obtain input from employees regarding the training they have received and suggestions for improving it.

6.0 Contractor Employers

The Project Manager is responsible for hazard communication information transmission to outside contractors of any chemical hazards which may be encountered in the normal course of work on the premises, the labeling system in use, safe handling measures, emergency response procedures, and the location of MSDS's. Each contractor bringing chemicals on-site must provide the prime contractor with the appropriate hazard information on these substances, the labeling system in use, safe handling procedures, and emergency response information.

125

Mallinckrodt

Material Safety Data

Emergency Phone Number: 314-982-5000

Mallinckrodt, Inc., Science Products Division, P.O. Box M, Paris, KY 43061.

[illegible]

HYDROCHLORIC ACID, 37%

PRODUCT IDENTIFICATION:

Synonyms: Muriatic acid

Formula CAS No.: 7647-01-0

Molecular Weight: 36.46 (HCl)

Chemical Formula: HCl

Hazardous Ingredients: Not Applicable

PRECAUTIONARY MEASURES

DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. INHALATION MAY CAUSE LUNG DAMAGE.

Do not get in eyes, on skin, or on clothing.
Avoid breathing mist.
Use only with adequate ventilation.
Wash thoroughly after handling.
Store in a tightly closed container.
Remove and wash contaminated clothing promptly.
This substance is classified as a POISON under the Federal Caustic Poison Act.

EMERGENCY/FIRST AID

In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. If swallowed, DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In all cases call a physician.
SEE SECTION 5.

DOT Hazard Class: Corrosive Material

SECTION 1 Physical Data

Appearance: Clear, colorless fuming liquid.

Odor: Pungent odor of hydrogen chloride.

Solubility: Infinite in water with slight evolution of heat.

Boiling Point: 53°C (127°F); Azeotrope (20.2%) boils at 109°C (228°F)

Melting Point: -74°C (-101°F)

Specific Gravity: 1.18

Vapor Density (Air = 1): No information found.

Vapor Pressure (mm Hg): 190 @ 25°C (77°F)

Evaporation Rate: No information found.

SECTION 2 Fire and Explosion Information

Fire:
Can react with metals to release flammable hydrogen gas.

Explosion:
Not considered to be an explosion hazard.

Fire Extinguishing Media:
If involved in a fire, use water spray.

Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

SECTION 3 Reactivity Data

Stability:
Stable under ordinary conditions of use and storage. Containers may burst when heated.

Hazardous Decomposition Products:
When heated to decomposition, emits toxic hydrogen chloride fumes and will react with water or steam to produce heat and toxic and corrosive fumes.

Hazardous Polymerization:
Will not occur.

Incompatibilities:
A strong mineral acid, concentrated hydrochloric acid is highly reactive with strong bases, metals, metal oxides, hydroxides, amines, carbonates and other alkaline materials. Incompatible with materials such as cyanides, sulfides, sulfites, and formaldehyde.

SECTION 4 Leak/Spill Disposal Information

Clean-up personnel should wear protective clothing and respiratory equipment suitable for toxic or corrosive fluids or vapors. Isolate or enclose the area of the leak or spill.
Small Spills: Flush with water and neutralize with alkaline material (soda ash, lime, etc.). Sewer neutralized material with excess water. Larger spills and lot sizes: Neutralize with alkaline material, pick up with absorbent material (sand, earth, vermiculite). Provide forced ventilation to dissipate fumes. Dispose in a RCRA-approved waste facility or sewer the neutralized slurry with excess water if local ordinances allow.

Reportable Quantity (RQ)(CWA/CERCLA) : 5000 lbs.

Ensure compliance with local, state and federal regulations.

NFPA Ratings: Health: 3 Flammability: 0 Reactivity: 0

Effective Date: 09-10-86 Supersedes 08-21-85

SECTION 5 Health Hazard Information

A. EXPOSURE / HEALTH EFFECTS

Inhalation:
Corrosive! Inhalation of vapors can cause coughing, choking, inflamation of the nose, throat, and upper respiratory tract. Inhalation of higher concentrations may cause lung damage.

Ingestion:
Corrosive! Swallowing hydrochloric acid can cause immediate pain and burns of the mouth, throat, esophagus and gastrointestinal tract. May cause nausea, vomiting, and diarrhea.

Skin Contact:
Corrosive! Can cause redness, pain, and severe skin burns. Concentrated solutions cause deep ulcers and discolor skin.

Eye Contact:
Corrosive! Vapors are irritating and may cause damage to the eyes. Splashes may cause severe burns and permanent eye damage.

Chronic Exposure:
Long-term exposure to concentrated vapors may cause erosion of teeth. Long term exposures seldom occur due to the corrosive properties of the acid.

Aggrevation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye disease may be more susceptible to the effects of this substance.

B. FIRST AID

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Ingestion:
DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Exposure:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Eye Exposure:
Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

C. TOXICITY DATA (RTECS, 1982)

Oral rat LD50: 900 mg/kg (Hydrochloric acid concentrated) Mutation references cited.

SECTION 6 Occupational Control Measures

Airborne Exposure Limits:
-OSHA Permissible Exposure Limit (PEL):
5 ppm (TWA) Ceiling
-ACGIH Threshold Limit Value (TLV):
5 ppm (TWA) Ceiling

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, "Industrial Ventilation, A Manual of Recommended Practices", most recent edition, for details.

Personal Respirators: (NIOSH Approved)
If the TLV is exceeded a full facepiece chemical cartridge respirator may be worn, in general, up to 100 times the TLV or the maximum use concentration specified by the respirator supplier, whichever is less. Alternatively, a supplied air full facepiece respirator or airlined hood may be worn.

Skin Protection:
Rubber or neoprene gloves and additional protection including impervious boots, apron, or coveralls, as needed in areas of unusual exposure to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible.Contact lenses should not be worn when working with this material. Maintain eye wash fountain and quick-drench facilities in work area.

SECTION 7 Storage and Special Information

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect from physical damage and direct sunlight. Isolate from incompatible substances. Protect from moisture.

……

Mallinckrodt
Material Safety Data

Emergency Phone Number: 314-982-5000

Mallinckrodt, Inc., Science Products Division, P.O. Box M, Paris, KY 43061.

NITRIC ACID, 70%

PRODUCT IDENTIFICATION:

Synonyms: Aqua Fortis; Azotic Acid; Nitric Acid 70%

Formula CAS No.: 7697-37-2

Molecular Weight: 63.00

Chemical Formula: HNO_3

Hazardous Ingredients: Not Applicable

PRECAUTIONARY MEASURES

DANGER! STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. INHALATION MAY CAUSE LUNG DAMAGE.

Do not get in eyes, on skin, or on clothing.
Avoid breathing mist.
Use only with adequate ventilation.
Wash thoroughly after handling.
Keep from contact with clothing and other combustible materials.
Do not store near combustible materials.
Store in a tightly closed container.
Remove and wash contaminated clothing promptly.
This substance is classified as a POISON under the Federal Caustic Poison Act.

EMERGENCY/FIRST AID

In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. If swallowed, DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In all cases call a physician.
SEE SECTION 5.

DOT Hazard Class: Oxidizer

SECTION 1 Physical Data

Appearance: Clear, colorless to slightly yellow liquid.

Odor: Suffocating acrid.

Solubility: Infinite in water.

Boiling Point: 122°C (252°F)

Melting Point: -34°C (-29°F)

Specific Gravity: 1.41

Vapor Density (Air=1): 2-3 approximately

Vapor Pressure (mm Hg): 62 @ 20°C (68°F)

Evaporation Rate: No information found.

SECTION 2 Fire and Explosion Information

Fire:
Not combustible, but substance is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition. Can react with metals to release flammable hydrogen gas.

Explosion:
Reacts explosively with combustible organic or readily oxidizable materials such as: alcohols, turpentine, charcoal, organic refuse, metal powder, hydrogen sulfide, etc.

Fire Extinguishing Media:
If involved in a fire, use water spray.

Special Information:
Increases the flammability of combustible, organic and readily oxidizable materials. In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

SECTION 3 Reactivity Data

Stability:
Stable under ordinary conditions of use and storage. Containers may burst when heated.

Hazardous Decomposition Products:
When heated to decomposition, emits toxic nitrogen oxides fumes and hydrogen nitrate. Will react with water or steam to produce heat and toxic and corrosive fumes.

Hazardous Polymerization:
Will not occur.

Incompatibilities:
A dangerously powerful oxidizing agent, concentrated nitric acid is incompatible with most substances, especially strong bases, metallic powders, carbides, hydrogen sulfide, turpentine, and combustible organics.

SECTION 4 Leak/Spill Disposal Information

Isolate or enclose the area of the leak or spill. Clean-up personnel should wear protective clothing and respiratory equipment suitable for toxic or corrosive fluids or vapors.
Small Spills: Flush with water and neutralize with alkaline material (soda ash, lime, etc.). Sewer with excess water.
Larger spills and lot sizes: Neutralize with alkaline material, pick up with absorbent material (sand, earth, vermiculite) and dispose in a RCRA-approved waste facility or sewer the neutralized slurry with excess water if local ordinances allow.
Provide forced ventilation to dissipate fumes.

Reportable Quantity (RQ)(CWA/CERCLA) : 1000 lbs.

Ensure compliance with local, state and federal regulations.

AD

NFPA Ratings: Health: 3 Flammability: 0 Reactivity: 0 Other: Oxidizer

SECTION 5 Health Hazard Information

A. EXPOSURE / HEALTH EFFECTS

Inhalation:
Corrosive! Inhalation of vapors can cause breathing difficulties and lead to pneumonia and pulmonary edema, which may be fatal. Other symptoms may include coughing, choking, and irritation of the nose, throat, and respiratory tract.

Ingestion:
Corrosive! Swallowing nitric acid can cause immediate pain and burns of the mouth, throat, esophagus and gastrointestinal tract.

Skin Contact:
Corrosive! Can cause redness, pain, and severe skin burns. Concentrated solutions cause deep ulcers and stain skin a yellow or yellow-brown color.

Eye Contact:
Corrosive! Vapors are irritating and may cause damage to the eyes. Splashes may cause severe burns and permanent eye damage.

Chronic Exposure:
Long-term exposure to concentrated vapors may cause erosion of teeth. Long term exposures seldom occur due to the corrosive properties of the acid.

Aggrevation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye disease may be more susceptible to the effects of this substance.

B. FIRST AID

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Ingestion:
DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Exposure:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Eye Exposure:
Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

C. TOXICITY DATA (RTECS, 1982)

Inhalation (Rat) LC50: 244 ppm
(NO_2)/30M

SECTION 6 Occupational Control Measures

Airborne Exposure Limits:
-OSHA Permissible Exposure Limit (PEL):
2 ppm (TWA)
-ACGIH Threshold Limit Value (TLV):
2 ppm (TWA); 4ppm (STEL)

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, "Industrial Ventilation, A Manual of Recommended Practices", most recent edition, for details.

Personal Respirators: (NIOSH Approved)
If the TLV is exceeded, wear a supplied air, full-facepiece respirator, airlined hood, or self-contained breathing apparatus. Nitric acid is an oxidizer and should not come in contact with cartridges and cannisters that contain oxidizable materials, such as activated charcoal.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible.Contact lenses should not be worn when working with this material. Maintain eye wash fountain and quick-drench facilities in work area.

SECTION 7 Storage and Special Information

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect from physical damage and direct sunlight. Isolate from incompatible substances. Protect from moisture.

••

Mallinckrodt
Material Safety Data

Emergency Phone Number: 314-982-5000

Mallinckrodt, Inc., Science Products Division, P.O. Box M, Paris, KY 43061.

SULFURIC ACID 96%

PRODUCT IDENTIFICATION:

Synonyms: Oil of Vitriol

Formula CAS No.: 7664-93-9

Molecular Weight: 98.07

Chemical Formula: H_2SO_4

Hazardous Ingredients: Not applicable.

PRECAUTIONARY MEASURES

DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. INHALATION MAY CAUSE LUNG DAMAGE.

Do not get in eyes, on skin, or on clothing.
Do not breathe mist.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
This substance is classified as a POISON under the Federal Caustic Poison Act.

EMERGENCY/FIRST AID

In all cases call a physician. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. If swallowed, DO NOT INDUCE VOMITING! Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
SEE SECTION 5.

DOT Hazard Class: Corrosive Material

SECTION 1 Physical Data

Appearance: Colorless, oily liquid.

Odor: Odorless.

Solubility: Infinite @ 20°C.

Boiling Point: ca. 310°C (590°F)

Melting Point: ca. -14°C (6°F).

Specific Gravity: 1.84

Vapor Density (Air=1): < 0.3 @ 25°C (77°F)

Vapor Pressure (mm Hg): 1 @ 146°C (250°F).

Evaporation Rate: No information found.

SECTION 2 Fire and Explosion Information

Fire:
Not combustible, but substance is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition. Reacts with most metals releasing flammable, potentially explosive hydrogen gas.

Explosion:
Not combustible, but substance is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition.

Fire Extinguishing Media:
Dry chemical, foam or carbon dioxide. Water spray may be used to keep fire exposed containers cool.

Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

SECTION 3 Reactivity Data

Stability:
Stable under ordinary conditions of use and storage.

Hazardous Decomposition Products:
Toxic fumes of oxides of sulfur. Will react with water or steam to produce toxic and corrosive fumes. Reacts with carbonates to generate carbon dioxide gas, and with cyanides and sulfides to form poisonous hydrogen cyanide and hydrogen sulfide respectively.

Hazardous Polymerization:
Will not occur.

Incompatibilities:
Water, bases, organic material, halogens, metal acetylides, oxides and hydrides, strong oxidizing and reducing agents and many other reactive substances.

SECTION 4 Leak/Spill Disposal Information

Dike and cover leaking or spilled liquid with dirt, vermiculite, kitty-litter or other inert absorbent. Cover spill with sodium bicarbonate or soda ash and mix. Clean-up personnel require protective clothing and respiratory protection from vapors and mists. Neutralized waste may be containerized and disposed in a RCRA approved waste disposal facility. Flush area of spill with dilute soda ash solution and discard to sewer.

Reportable Quantity (RQ)(CWA/CERCLA) : 1000 lbs.

Ensure compliance with local, state and federal regulations.

NFPA Ratings: Health: 3 Flammability: 0 Reactivity: 2 Other: Water reactive

SECTION 5 Health Hazard Information

A. EXPOSURE / HEALTH EFFECTS

Inhalation:
Inhalation produces damaging effects on the mucous membranes and upper respiratory tract. May cause lung edema. Symptoms may include irritation of the nose and throat, and labored breathing.

Ingestion:
Corrosive. Swallowing can cause severe burns of the mouth, throat, and stomach, leading to death. Can cause sore throat, vomiting, diarrhea.

Skin Contact:
Corrosive. Symptoms of redness, pain, and severe burn can occur.

Eye Contact:
Corrosive. Splashes can cause blurred vision, redness, pain and severe tissue burns.

Chronic Exposure:
Long-term exposure to mist or vapors may cause damage to teeth.

Aggrevation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

B. FIRST AID

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Ingestion:
If swallowed, DO NOT induce vomiting. Give large quantities of water or milk if available. Call a physician immediately. Never give anything by mouth to an unconscious person.

Skin Exposure:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician.

Eye Exposure:
Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

C. TOXICITY DATA (RTECS, 1982)

Oral rat LD50: 2140 mg/kg. Inhalation Guinea Pig LC50: 18 mg/m^3.

SECTION 6 Occupational Control Measures

Airborne Exposure Limits:
-OSHA Permissible Explosure Limit (PEL):
1 mg/m^3 (TWA).
-ACGIH Threshold Limit Value (TLV):
1 mg/m^3 (TWA).

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, "Industrial Ventilation, A Manual of Recommended Practices", most recent edition, for details.

Personal Respirators: (NIOSH Approved)
If the TLV is exceeded a full facepiece chemical cartridge respirator may be worn, in general, up to 100 times the TLV or th maximum use concentration specified by the respirator supplier, whichever is less. Alternatively, a supplied air full facepiece respirator or airlined hood may be worn.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible.Contact lenses should not be worn when working with this material. Maintain eye wash fountain and quick-drench facilities in work area.

SECTION 7 Storage and Special Information

Store in a cool, dry, ventilated storage area with acid resistant floors and good drainage. Protect from physical damage Keep out of direct sunlight and away from heat, water, and incompatible materials. Do not wash out container and use it for other purposes. When diluting, always add the acid to water; neve add water to the acid.

••

Mallinckrodt®

SODIUM HYDROXIDE

Material Safety Data Sheet

Emergency Telephone Number
314-982-5000

Mallinckrodt Inc.
Science Products Division
P.O. Box M
Paris, Kentucky 40361

Effective Date: 11-03-85

PRODUCT IDENTIFICATION:

Synonyms: Caustic soda; lye; sodium hydroxide solid; sodium hydrate

Formula CAS No.: 1310-73-2

Molecular Weight: 40.00

Hazardous Ingredients:
None.

Chemical Formula: NaOH

PRECAUTIONARY MEASURES

DANGER! MAY BE FATAL IF SWALLOWED. CAUSES SEVERE BURNS.

Do not get in eyes, on skin, or on clothing.
Avoid breathing dust.
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.
This substance is classified as a POISON under the Federal Caustic Poison Act.

EMERGENCY/FIRST AID

If swallowed, do NOT induce vomiting. Give large quantities of water. Never give anything by mouth to an unconscious person. Call a physician immediately. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. In all cases call a physician.

SEE SECTION 5.

DOT Hazard Class: Corrosive Material

Physical Data SECTION 1

Appearance: White, deliquescent pellets.

Odor: Odorless.

Solubility: 111 g/100 g of water.

Boiling Point: 1390°C (2534°F)

Vapor Density (Air=1): No information found.

Melting Point: 318°C (604°F)

Vapor Pressure (mm Hg): Negligible.

Specific Gravity (water=1): 2.13

Evaporation Rate: No information found.

Fire and Explosion Information SECTION 2

Fire: Not considered to be a fire hazard.
Hot or molten material can react violently with water.
Can react with certain metals, such as aluminium, to generate flammable hydrogen gas.

Explosion. Not considered to be an explosion hazard.

Fire Extinguishing Media: Use any means suitable for extinguishing surrounding fire. Adding water to caust solution generates large amounts of heat.

Special Information. In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

Reactivity Data SECTION 3

Stability. Stable under ordinary conditions of use and storage. Very hygroscopic. Can slowly pick up moisture from air and react with carbon dioxide in air to form sodium carbonate.

Hazardous Decomposition Products:

Hazardous Polymerization: This substance does not polymerize.

Incompatibilities: Contact with water, acids, flammable liquids, and organic halogen compounds, especially trichloroethylene, may cause fire or explosion. Contact with nitromethane and other similar nitro compounds causes formation of shock-sensitive salts. Contact with metals such as aluminum, tin, and zinc causes formation of flammable hydrogen gas.

Leak/Spill Disposal Information SECTION 4

This is a test line 1000°C.
Clean-up personnel require protective clothing and respiratory protection from dust. Sweep, scoop or pick up spilled material. Avoid dusting. Collected waste may be transferred to a closed, preferably metal, container and sent to a RCRA-approved waste disposal facility. Do not flush to the sewer. Caution! Floor and other surfaces may be slippery. Do not contact with water. Neutralize traces with dilute acid.

Ensure compliance with local, state and federal regulations.

lealth Hazard Information SECTION 5

Exposure/Health Effects

Inhalation:	Severe irritant. Effects from inhalation of dust or mist vary from mild irritation to serious damage of the upper respiratory tract, depending on severity of exposure. Severe pneumonitis may occur.
Ingestion:	Corrosive! Swallowing may cause severe burns of mouth, throat, and stomach. Severe scarring of tissue and death may result.
Skin Contact:	Corrosive! Contact of skin can cause irritation or severe burns and scarring with greater exposures
Eye Contact:	Corrosive! May cause irritation of eyes, and with greater exposures, severe burns with possibly blindness resulting.
Chronic Exposure:	Prolonged contact with dilute solutions or dust has a destructive effect upon tissue.
Aggravation of Pre-existing Conditions:	Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

FIRST AID

Inhalation:	Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
Ingestion:	DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Skin Exposure:	In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Call a physician immediately.
Eye Exposure:	Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

C. TOXICITY DATA (RTECS, 1982)

No LD50/LC50 information found relating to normal routes of occupational exposure.

Irritation data: Skin, rabbit: 50 mg/24H Severe
Eye, rabbit: 50 mg/24H Severe

Occupational Control Measures SECTION 6

Airborne Exposure Limits.	·OSHA Permissible Exposure Limit (PEL): 2 mg/m^3 (TWA) ·ACGIH Threshold Limit Value (TLV): 2 mg/m^3 (Ceiling)
Ventilation System.	A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, "Industrial Ventilation, A Manual of Recommended Practices", most recent edition, for details.
Personal Respirators (NIOSH Approved)	If the TLV is exceeded, a dust/mist respirator with chemical goggles may be worn, in general, up to ten times the TLV. Consult respirator supplier for limitations. Alternatively, a supplied air full facepiece respirator or airlined hood may be worn.
Skin Protection:	Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls to prevent skin contact.
Eye Protection	Use chemical safety goggles and/or a full face shield where splashing is possible. Contact lenses should not be worn when working with this material. Maintain eye wash fountain and quick-drench facilities in work area.

Storage and Special Information SECTION 7

Keep in a tightly closed container. Protect from physical damage. Store in a cool, dry, ventilated area away from sources of heat, moisture and incompatibilities. Always add the caustic to water while stirring; never the reverse.

****

The information contained herein is provided in good faith and is believed to be correct as of the date hereof. However, Mallinckrodt, Inc. makes no representation as to the comprehensiveness or accuracy of the information. It is expected that individuals receiving the information will exercise their independent judgment in determining its appropriateness for a particular purpose. Accordingly, Mallinckrodt, Inc. will not be responsible for damages of any kind resulting from the use of or reliance upon such information. NO REPRESENTATIONS, OR WARRANTIES, EITHER EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OF ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR TO THE PRODUCT TO WHICH THE INFORMATION REFERS.

****

HARCROS CHEMICALS INC
KANSAS CITY, KANSAS

MATERIAL SAFETY DATA SHEET

PRODUCT NAME: BENTONITE POWDER 200M 100# DATE: 12/11/90 PAGE 01
PRODUCT CODE: 16-05629-03

CAS # 001302-76-7

FORMULA: Al(2)O(3)SiO(2).H(2)O

CHEMICAL FAMILY: Alumino - Silicate

CHEMICAL NAME AND SYNONYMS: Bentonite, Western Bentonite, Swelling Western Bentonite, Sodium Montmorillonite, Chlorite, Hydrous Silicate of Alumina

SUPPLIERS NAME: Harcros Chemicals Inc
5200 Speaker Rd
Kansas City Ks 66106
SUPPLIERS PHONE NUMBER: 913-321-3131
TRANSPROTATION EMERGENCY PHONE NUMBER: 1-800-424-9300

S.A.R.A. INFORMATION

HAZARDS: Fire:No Pressure:No Reactivity:No Acute: No Chronic:Yes
PHYSICAL DATA: Mixture:Yes Pure:No Solid:Yes Liquid:No Gas:No

SECTION I Hazardous Ingredients

Ingredient	Percent	TLV
Crystalline Silica (CAS # 14464-46-1)	<6	PEL .05 mg/m(3) OSHA TLV TWA 8Hr 0.05 mg/m(3) Respirable Silica ACGIH 0.05 mg/m(3) 10 Hr TWA Respirable Silica NIOSH

SECTION II Health Hazards

Threshold Limit Value:

As indicated in Section I.

Potential Effects of Exposure:

Eyes: May be irritating to eyes.

Skin: May irritate skin

Inhalation: May be irritant to nose and throat. Short term overexposure to silica can produce cough, wheezing, and dyspnea. Long term overexposure to silica causes silicosis, a form of pulmonary fibrosis. Continued exposure to silica can lead to cardiopulmonary impairment.

Ingestion: N/A

First aid:

Eyes: Flush eyes with large amounts of water for at least 15 minutes. Hold eyelids apart to ensure flushing of the entire eye surface. Seek medical attention if irritation persists.

Skin: Wash with soap and water. If irritation occurs or persists, get medical attention. Remove and launder contaminated

CONTINUED ON PAGE 02

MATERIAL SAFETY DATA SHEET

PRODUCT NAME: BENTONITE POWDER 200M 100# DATE: 12/11/90 PAGE 03
PRODUCT CODE: 16-05629-03

SECTION IV Fire & Explosion Hazard Data

CONTINUED

Special Fire Fighting Procedures: N/A

Unusual Fire and Explosion Hazards: N/A

SECTION V Physical Data

Boiling Point: N/A

Specific Gravity (H_2O=1): 2.58

Vapor Pressure (MM HG.): N/A

Vapor Density (AIR=1): N/A

Evaporation Rate (_____=1): N/A

Solubility in Water: Insoluble

Percent Volatile by Volume: N/A

pH: approx 9.5

Appearance and Odor: White, yellow, blue or brown powder, earthy odor.

SECTION VI Reactivity Data

Stability: Stable

Incompatibility: None

Hazardous Decomposition Products: None

Hazardous Polymerization: Will not occur

SECTION VII Spill and Leak Procedures

Steps to be taken if material is released or spilled:

Provide ventilation. Clean-up personnel need protection against eye contact and inhalation of dust. Vacuum or wet sweeping is recommended in picking up spills. Be cautious, Bentonite becomes slippery when moistened. Place waste product in closed container. If uncontaminated, recover for use.

Waste Disposal Method:

Dispose of the waste product in an approved facility in accordance with applicable federal, state, and local regulations.

CONTINUED ON PAGE 04

EISENMAN CHEMICAL COMPANY
PRODUCT TRANSPORTATION, ENVIRONMENTAL, AND SAFETY SHEET

A-93

SECTION I

SUPPLIER: Black Hills Bentonite and Eisenman Chemical Company
Telephone: (307) 265-3740
TELEPHONE: 330-1600
ADDRESS: 4687 18th-Street, Greeley, Colorado 80634
TRADE NAME: [illegible] GEL (Hi-Yield and Untreated)
GENERIC DESCRIPTION: Sodium Bentonite

SECTION II HAZARDOUS INGREDIENTS

COMPONENT	%
Sodium Bentonite	81.5
Water(adsorbed)	8
Water(Chemically Bonded)	6
Free Silica	4.5

HAZARD DATA
Excessive inhalation of silica may produce debilitating lung disease. Silica TLV is 0.1 mg/m^3, respirable dust. Cas No. 14808-60-7

SECTION III PHYSCIAL DATA

FUSION POINT (F): 2440
SPECIFIC GRAVITY: 2.6
VAPOR PRESSURE (mm Hg): 0
%VOLATILES BY VOLUME: 0
VAPOR DENSITY (AIR=1): N/A
EVAPORATION RATE: N/A
SOLUBILITY IN WATER: NEGLIGIBLE
pH (2% SOLUTION): 7-9
APPEARANCE AND ODOR: Yellow, tan to blue granules or powder, earthy odor.

SECTION IV FIRE AND EXPLOSION DATA

FLASH POINT: Sodium bentonite is an inorganic mineral. It is non-flammable and non-hazardous.

DOT INFORMATION not regulated
PROPER SHIPPING NAME:
HAZARD CLASS:
HAZARDOUS SUBSTANCE:
LABEL:

NIOSH RATINGS
HEALTH HAZARD: 1
FLAMMABILITY: 0
REACTIVITY: 0

SECTION V HEALTH HAZARD INFORMATION

PEL: 4 mg/m^3 total dust, 1.5 mg/m^3 respirable dust.

ROUTES OF EXPOSURE AND EFFECTS: Short Term: No effect other than as a nuisance dust. Long-term: Long-term exposure to dust concentrations higher than recommended permissible exposure limits may cause debilitating lung disease. Intravenous (rats) LD_{50}: 35 mg/kg. Oral - None known. However, bentonite is used as pellet binders in animal feeds.
EMERGENCY AND FIRST AID PROCEDURES: Flush eyes thoroughly with water, see a physician if irritation persists. If inhaled, remove to fresh air. If irritation persists, consult a physician.

EISENMAN CHEMICAL COMPANY TEASS FOR
ECCO-GEL (Hi-Yield and Untreated)

SECTION VI REACTIVITY DATA

STABILITY: Stable

CONDITIONS/MATERIALS TO AVOID:
None

HAZARDOUS DECOMPOSITION PRODUCTS: None

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED: If uncontaminated, sweep up or collect, and reuse as product. If contaminated with other materials, collect in suitable containers. Avoid dusting conditions.

WASTE DISPOSAL METHOD: Can be disposed of by burial in an approved land disposal facility, in accordance with applicable federal, state, and local regulations.

SECTION VIII INDUSTRIAL HYGIENE REQUIREMENTS

VENTILATION: Local exhaust or other ventilation that will reduce dust concentrations to less than PEL is recommended

PERSONAL PROTECTIVE EQUIPMENT:

RESPIRATORY: If dust concentrations exceed recommended PEL, Use NIOSH approved dust respirators, with approval TC-21C, until engineering controls are completed.

EYE: If high dust concentrations exist, tight-fitting goggles or full face piece respirators with dust filters are recommended to reduce employee exposure.

SKIN: N/A

OTHER RECOMMENDED EQUIPMENT/CLOTHING: N/A

SECTION IX SPECIAL PRECAUTIONS

No special precautions are needed for using or handling this material, other than to keep dust concentrations low. Spilled material is slippery when wet.

PREPARED BY: PREPARATION/REVISION DATE: 8/30/85
EISENMAN CHEMICAL COMPANY TECHNICAL SERVICES

PureGold®
Groundwater Monitoring Products

AMERICAN COLLOID COMPANY
Water/Mineral Division

AMERICAN COLLOID COMPANY'S
VOLCLAY PURE GOLD PRODUCT LINE

VOLCLAY TABLETS

DESCRIPTION: Volclay tablets are organic free, high-swelling 100% pure sodium bentonite. The tablets are compressed into 1/2", 3/8" and 1/4" in diameters.

RECOMMENDED USE: Volclay tablets are designed for use in the groundwater monitoring industry. They form a chemically resilient, low permeable, flexible seal. The tablet will isolate screened intervals of monitoring wells and provide an excellent seal for abandoned boreholes. The 1/4" tablets are ideal for providing seals in tight annulus spaces while the 3/8" and 1/2" tablets are useful for larger borehole sealing.

CHARACTERISTICS:

- Chemically stable, results from EP Toxicity Metals Analysis are below RCRA limits for hazardous constituents
- Permeability rang of 1×10^{-7} to 1×10^{-9} cm/sec
- High swell capacity, tablets swell 10 to 15 times their dry volume when hydrated with fresh water
- Self sealing, remains flexible when saturated and will rehydrate

APPLICATION:

For shallow applications Volclay tablets should be added slowly and steadily to prevent blocking and bridging. For deep applications tablets may be tremied into place. Tablets are added and water is pumped down the tremie pipe delivering the tablet to the desired depth quickly and accurately.

PACKAGING: Volclay tablets are shipped in 50 lb. plastic pails, 36 pails per pallet and stretch-wrapped. Tablets may also be purchased in 600 lb./55 gallon fiber drums.

AMERICAN COLLOID COMPANY

One North Arlington • 1500 West Shure Drive
Arlington Heights, Illinois 60004-1434 • USA
(312) 392-4600 • Telex ITT 4330321
Fax (312) 506-6199

51401
5141

MATERIAL SAFETY DATA SHEET - May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Standard must be consulted for specific requirements.

PRODUCT NAME: 1/2" VOLCLAY TABLETS

Section I MANUFACTURER'S INFORMATION

Manufacturer's Name & Address:

American Colloid Company
1500 West Shure Drive
One North Arlington
Arlington Heights, Illinois 60004

Emergency Telephone Number: 312-392-4600
Telephone Number for Information: 312-392-4600
Date Prepared: August 31, 1988

Section II HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

Hazardous Components (Specific Chemical Identity: Common Name(s))		OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
Crystalline Quartz CAS# 14808-60-7		-	-	*	2-6%
Total Dust (Quartz)	$\frac{30mg/m^3}{\%SiO_2+2}$ =	$3mg/m^3$	-	-	-
Respirable Crystalline Quartz				NIOSH	
present (TWA)	$\frac{10mg/m^3}{\%SiO_2+2}$ =	$1mg/m^3$	$0.1mg/m^3$ TWA	$50ug/m^3$ TWA	<2%
proposed (TWA)		$0.1mg/m^3$	$50ug/m^3$ TWA	-	-
Total Nuisance Dust		$15mg/m^3$	$10mg/m^3$	-	-
Respirable Nuisance Dust		$5mg/m^3$	$5mg/m^3$	-	-

* WARNING:
This clay product contains a small amount of crystalline silica which may cause delayed respiratory disease if inhaled over a prolonged period of time. Avoid breathing dust. Use NIOSH/MSHA approved respirator where TLV for crystalline silica may be exceeded. IARC Monographs on the evaluation of the Carcinogenic Risk of Chemicals to Humans (volume 42, 1987) concludes that there is "limited evidence" of the carcinogenicity of crystalline silica to humans. IARC classification 2A.

PRODUCT IDENTIFICATION

Chemical Name: Bentonite Clay
Chemical Family: Natural Mineral, Montmorillonite
CAS No.: 1302-78-9
FORMULA: Naturally occurring hydrated aluminosilicate of sodium, calcium, magnesium, and iron
NFPA/HMIS: Health - 0, Fire - 0, Reactivity - 0, Specific Hazard - See Section VI
Dot Class: Not Regulated

AGC

AMERICAN COLLOID COMPANY

One North Arlington • 1500 West Shure Drive
Arlington Heights, Illinois 60004-1434 • USA
(312) 392-4600 • Telex ITT 4330321
Fax (312) 506-6199

51401
5141

PRODUCT NAME: 1/2" VOLCLAY TABLETS

Section III PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point - Not Applicable
Vapor Pressure (mm Hg.) - Not Applicable
Vapor Density (AIR = 1) - Not Applicable
Solubility in Water - Negligible
Appearance and Odor - Pale grey to buff tablets, odorless

Specific Gravity (H_2O = 1) - 2.5
Melting Point - Not Applicable
Evaporation Rate (Butyl Acetate = 1) - Not Applicable

Section IV FIRE AND EXPLOSION HAZARD DATA

Flash Point (Method Used) - Not Applicable
Flammable Limits - Not Applicable LEL- - UEL- -
Extinguishing Media - Not Applicable
Special Fire Fighting Procedures - Inorganic Mineral/Non-Flammable
Unusual Fire and Explosion Hazards - Not Applicable

Section V REACTIVITY DATA

Stability Unstable - Conditions to Avoid - None Known
Stable - X

Incompatibility (Materials to Avoid) - None Known
Hazardous Decomposition or By-products - None Known

Hazardous Polymerization May Occur - Conditions to Avoid - None Known
Will Not Occur - X

Section VI HEALTH HAZARD DATA

Route(s) of Entry: Inhalation? Yes Skin? No Ingestion? No

Health Hazards (Acute and Chronic) - May cause delayed respiratory disease if dust inhaled over a prolonged period of time.

Carcinogenicity: NTP? No IARC Monographs? Yes OSHA Regulated? No

IARC Monographs on the evaluation of the Carcinogenic Risk of Chemicals to Humans (volume 42, 1987) concludes that there is "limited evidence" of the carcinogenicity of crystalline silica to humans. IARC classification 2A.

Signs and Symptoms of Exposure - Excessive inhalation of dust may result in shortness of breath and reduced pulmonary function.

Medical Conditions Generally Aggravated by Exposure - Individuals with pulmonary and/or respiratory disease including but not limited to asthma and bronchitis should be precluded from exposure to dust.

Emergency and First Aid Procedures - Eyes - Flush with water.
- Gross inhalation of dust - Remove to fresh air; give oxygen or artificial respiration if necessary; get medical attention.

AMERICAN COLLOID COMPANY

One North Arlington • 1500 West Shure Drive
Arlington Heights, Illinois 60004-1434 • USA
(312) 392-4600 • Telex ITT 4330321
Fax (312) 506-6199

51401
5141

PRODUCT NAME: 1/2" VOLCLAY TABLETS

Section VII PRECAUTIONS FOR SAFE HANDLING AND USE

Steps to be Taken in Case Material is Released or Spilled - Vacuum if possible to avoid generating airborne dust. Avoid breathing dust. Wear an approved respirator. Avoid adding water, the product will become slippery when wet.

Waste Disposal Method - Follow federal, state and local regulations for solid waste.

Precautions to Be Taken in Handling and Storing - Avoid breathing dust, use NIOSH/MSHA approved respirator where TLV limits for Crystalline Silica may be exceeded.

Other Precautions - Slippery when wet.

Section VIII CONTROL MEASURES

Respiratory Protection (Specify Type) - OSHA standard 1910.134 or ANSI Z88.2-1980 specification.

Ventilation - Local Exhaust - As appropriate
- Mechanical (General) - As appropriate
Special - None Required
Other - None Required
Protective Gloves - Not Required
Eye Protection - Recommended
Other Protective Clothing or Equipment - None Required
Work/Hygienic Practices - Use good housekeeping practices.

AMERICAN COLLOID COMPANY

5100 Suffield Ct. • Skokie, IL 60077
(312) 966-5720
TWX 910-223-0738 • TELEX ITT 4330321

technical data

VOLCLAY GROUT CHEMICAL ANALYSIS

GENERAL DESCRIPTION:	A Bentonite based product formulated for use as a non-bridging, high solids clay grout.
FUNCTIONAL USE:	Useful for sealing and grouting well casings, plugging abandoned wells and waterproofing earthen structures.

CHEMICAL COMPOSITION:

	PERCENT	
SiO_2	56.2	Silica
Al_2O_3	13.6	Alumina
CaO	1.53	Calcium
MgO	5.40	Magnesium
Na_2O	2.92	Sodium Oxide
K_2O	.66	Potassium Oxide
Fe_2O_3	3.07	Iron (Ferric)
TiO_2	.22	Titanium dioxide
Mn_3O_4	.05	Manganese Oxide
P_2O_5	1.22	Phosphorus Pentoxide
L.O.I.	14.8	Loss on Ignition

MOISTURE CONTENT:	Maximum 12% as shipped
pH:	5% suspension 9 to 10.5
BULK DENSITY:	55 lbs./cubic ft.
SPECIFIC GRAVITY:	2.5 g/c.c
HANDLING PRECAUTION:	Non toxic, avoid breathing dust.
PACKAGING:	50 lb. net wt. paper bag plus 2 lb. initiator bag.

31.2150

IDEAL Ideal Basic Industries
Cement Division

SILO TEST CERTIFICATE
AVERAGE OF TEST RESULTS

CONSIGNEE: TYPICAL ANALYSIS
PORTLAND PLANT
COLORADO SALES DIVISION
DENVER, CO 80222

CAR OR TRUCK NO:

MILL TEST NO:

BILL OF LADING NO:

DATE SHIPPED: 06-06-89

JOB NUMBER:

A S T M DESIGNATION: C150-88

PORTLAND CEMENT--TYPE: I-II LA

		PERCENT
CHEMICAL COMPOSITION:	SILICON DIOXIDE (SIO2)	20.7
	ALUMINUM OXIDE (AL2O3)	5.0
	FERRIC OXIDE (FE2O3)	3.4
	CALCIUM OXIDE (CAO)	64.6
	MAGNESIUM OXIDE (MGO)	1.2
	SULFUR TRIOXIDE (SO3)	2.8
	LOSS ON IGNITION	1.4
	INSOLUBLE RESIDUE	0.27
	TRICALCIUM SILICATE (C3S)	59
	DICALCIUM SILICATE (C2S)	15
	TRICALCIUM ALUMINATE (C3A)	7.6
	TETRACALCIUM ALUMINOFERRITE (C4AF)	10
	ALKALIES (NA2O EQUIVALENT)	0.41
SPECIFIC SURFACE:	BLAINE, SQ M PER KILOGRAM	399
SOUNDNESS:	AUTOCLAVE EXPANSION	0.02-

TIME OF SETTING: VICAT, INITIAL SET 90 MIN
VICAT, FINAL SET 195 MIN

COMPRESSIVE STRENGTH TESTS: 3 DAY 3210 LBS. PER SQ. IN.
7 DAY 4280 LBS. PER SQ. IN.

AIR ENTRAINMENT: PERCENT BY VOLUME 9.5

IDEAL CEMENT IS WARRANTED TO CONFORM AT THE TIME OF SHIPMENT WITH THE SPECIFICATION DESIGNATED ABOVE. NO OTHER WARRANTY IS MADE OR IMPLIED. HAVING NO CONTROL OVER THE USE OF ITS CEMENTS, IDEAL DOES NOT GUARANTEE FINISHED WORK.

IDEAL BASIC INDUSTRIES, INC.
CEMENT DIVISION
PORTLAND PLANT

BY ____________________
QUALITY CONTROL SUPERVISOR

31, 2150

OUR TOP OF THE LINE
Specialty Sands

Modern filtration and gravel pack methods require a filter medium that is 98% within specifications. This type of screening efficiency was virtually unheard of several years ago. Today, we produce these exotic materials on a daily basis. In fact, if you order a specialty sand, we'll screen it to a 99% spec to further assure satisfaction after shipping and handling.

Additional Exotic Sand Tests

Test	Sample Designation 10-14	10-16	Specification Limit
Mud-Acid Soluble, Wt. %			
Frac Sand	1 74	1.96	2.00 Max.
Gravel Pack Sand	0.91	0.89	1.00 Max.
Gravel Pack Crush Strength			
Gove Canyon 20-40 %	3.20		4.00 Max.

Size	98-100% Passing	98-100% Retained
6-9	#6 sieve	#10 sieve
8-12	#8	#12
10-14	#10	#14
10-16	#10	#16
16-20	#16	#20
20-30	#20	#30
20-40	#20	#40
40-60	#40	#60

Note: Materials processed to your Uniformity Coefficient and Effective Size, by separate quotation.

A Word of Caution—Since test results do vary, it is recommended that you confirm with your own lab your specification requirements and the physical and chemical characteristics of this product. We give no warranty for our products either expressed or implied.

Warning: This material contains free silica – do not breathe dust. May cause delayed lung injury. Wear government approved respirators and follow OSHA Safety and Health Standards for Silica.

OSHA PERMISSIBLE
EXPOSURE LIMIT (PEL):

	Mppcf	Mg/M^3
Crystalline Quartz (respirable)	$\frac{250}{\%SiO_2 + 5}$	$\frac{10mg/M^3}{\%SiO_2 + 2}$
Quartz (Total Dust)		$\frac{30mg/M^3}{\%SiO_2 + 2}$

See OSHA regulations as stated in CFR Title 29, Section 1910. 1000 Z-3 for Mineral Dusts, (respirable quartz). Exposure to airborne crystalline silica shall not exceed an 8-hour time-weighted average limit as set forth in CFR Title 29 above.

ACGIH TLV (Threshold Limit Value): Crystalline Quartz
TLV-TWA 0.1 mg/M$_3$ (Respirable Dust)
See Threshold Limit Value and Biological Exposure Indices for 1987-1988 · American Conference of Governmental Industrial Hygienists.

CHERRY CREEK SAND SPECIALTIES COMPANY
Phone: 755-1211
2510 So. Wabash Street, Denver, Colorado 80231

MATERIAL SAFETY DATA SHEET
(OSHA 29 CFR 1910.1200)

Product Name: Cherry Creek Sand &
various sizes of graded sand

SECTION I

Cherry Creek Sand Spec. Co.
2510 South Wabash Street
Denver, Colorado 80231

EMERGENCY TELEPHONE NUMBER

303-755-1211

Date of Preparation

March 8, 1988

Information Telephone Number

303-755-1211

SECTION II - HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

Hazardous Components	C.A.S. NO.	OSHA PEL	ACGIH TLV
Natural Silica Sand	7634-86-9	0.1 mg/m^3 as quartz	0.1mg/m^3

SECTION III -- PHYSICAL/CHEMICAL CHARACTERISTICS

Insoluble
Tan colored with no odor

The following properties are not applicable: specific gravity; boiling point; vapor pressure; vapor density; melt point; and evaporation rate.

SECTION IV -- FIRE AND EXPLOSION HAZARD DATA

Noncombustible and not explosive.

SECTION V -- REACTIVITY DATA

Is not incompatible with other materials. Will not decompose into hazardous by-products and will not polymerize.

Keep dry until used to preserve utility.

SECTION VI -- HEALTH HAZARD DATA

Exposure can affect the skin, the eyes, and mucous membranes.

Dust particles of respirable size dust from this product are hazardous to the respiratory system because of the presence of free silica.

Acute Exposure: Can dry the skin and cause alkali burns. Dust can irritate the eyes and upper respiratory system.

Chronic Exposure: Dust can cause inflamation of the lining tissue of the interior of the nose and inflamation of the cornea. Hypersensitive individuals may develop and allergic dermatitis. Over exposure to inhaled quartz dust may lead to chronic fibrotic lung disease known as silicosis, a form of disabling, progressive, and sometimes fatal pulmonary fibrosis. People with pre-existing lung diseases may have increased susceptibility to the health effect of respirable dusts.

Emergency First Aid Procedures: Irrigate (flood) eyes immediately and repeatedly with clean water. Wash exposed skin areas with soap and water. Get prompt medical attention.

SECTION VII -- PRECAUTIONS FOR SAFE HANDLING AND USE

If spilled, can be cleaned up using dry method that does not disperse dust into the air. Avoid breathing the dust. Emergency procedures are not required.

Can be treated as a common waste for disposal or returned to the container for later use if it is not contaminated or wet.

SECTION VIII -- CONTROL MEASURES

In dusty environments, the use of an OSHA, MSHA, or NIOSH approved respirator and tight fitting goggles is recommended.

Local exhaust can be used, if necessary, to control dust levels. The use of barrier creams or impervious gloves, boots, and clothing to protect the skin from contact is recommended. Following work, workers should shower with soap and water.

Colorado Silica Sand, Inc
3250 Drennan Industrial Loop
P.O. Box 15615
Colorado Springs, CO 80935
Phone (719) 390-7969
TWX: 910-920-4992
FAX: (719) 390-5517

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

IDENTITY:	Crystalline Silica (Quartz)
MANUFACTURER'S NAME:	Colorado Silica Sand, Inc.
ADDRESS:	3250 Drennan Industrial Loop P.O. Box 15615 Colorado Springs, CO 80935
EMERGENCY TELEPHONE NUMBER:	(719) 390-7969
TELEPHONE NUMBER FOR INFORMATION:	(719) 390-7969
DATE REVISED:	August 31, 1990
REPLACES:	September 12, 1988

SECTION II - HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

HAZARDOUS COMPONENTS:	Silica, Crystalline Quartz (respirable)
CHEMICAL NAME:	Silicon Dioxide $Si0_2$
FAMILY OR COMMON NAMES:	Silica sand; quartz; flint; sand; crystalline silica; free silica (a natural mineral extracted from the earth)
CHEMICAL ABSTRACT SERVICE NO.:	14808-60-7
TRADE NAME:	See Attachment A
OSHA PERMISSIBLE EXPOSURE LIMIT (PEL):	Exposure to airborne crystalline silica sand shall not exceed an 8-hour time-weighted average limit as stated in 29 CFR Section and Numbered Clause 1910.1000 specifically "Silica: Crystalline: Quartz (respirable) PEL - TWA = 0.1 Mg/M3

	Mppcf	Mg/M3
Crystalline Quartz (respirable)		$\frac{10mg/M3}{\%Si0_2 + 2}$
Quartz (Total Dust)	$\frac{250}{\%Si0_2 + 5}$	$\frac{30mg/M3}{\%Si0_2 + 2}$

ACGIH TLV (Threshhold Limit Value):	Crystalline Quartz TLV-TWA 0.1 mg/M3 (Respirable Dust) See Threshold Limit Value & Biological Exposure Indices for 1987-1988 -American Conference of Governmental Industrial Hygienists.
MSHA TLV (Threshhold Limit Value):	Exposure to airborne crystalline silica shall not exceed an 8-hour time-weighted average limit as stated in MSHA Standards, Subpart D, Section 56.5001 on Air Quality specifically "Silica: Crystalline: Quartz (respirable)

	Mg/M3
Crystalline Quartz (respirable)	$\frac{10\ mg/M3}{\%Si0_2 + 2}$

OTHER LIMITS RECOMMENDED:	National Institute for Occupational Safety and Health (NIOSH). Recommended standard maximum permissible concentration = 0.05 mg/M3 (respirable free silica) as determined by a full-shift sample up to 10-hour working day, 40-hour work week. See NIOSH Criteria for a Recommended Standard Occupational Exposure to Crystalline Silica.

SECTION III - PHYSICAL & CHEMICAL CHARACTERISTICS

APPEARANCE AND ODOR: Sand - granular, crushed or ground. No odor or taste.

COLOR: Tan or white

BOILING POINT: 4046 F.

SPECIFIC GRAVITY: (H_2O = 1): 2.65.

SOLUBILITY IN WATER: Insoluble

MELTING POINT: 3000 F.

VAPOR PRESSURE (mmHg at 20 C): None

VAPOR DENSITY (Air = 1): None

EVAPORATION RATE: (Butyl Acetate = 1): None

SECTION IV - FIRE AND EXPLOSION DATA

FLASH POINT: Non Flammable

FLAMMABLE LIMITS: None

LEL: None

UEL: None

FIRE EXTINGUISHING MATERIALS: N/A

USUAL FIRE AND EXPLOSION HAZARDS: None

SPECIAL FIRE FIGHTING PROCEDURES: None

SECTION V - REACTIVITY DATA

STABILITY: Stable (Inert - Neutral - Non-Reacting)

INCOMPATIBILITY (MATERIALS TO AVOID): Contact with powerful oxidizing agents such as flourine, chlorine, triflouride manganese trioxide, and oxygen diflouride may cause fires. Silica will dissolve in hydroflouric acid (HF) and produce a corrosive gas, silicon tetraflouride (S:F4).

HAZARDOUS DECOMPOSITION PRODUCTS INCLUDING COMBUSTION PRODUCTS: None

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: Generation of respirable quartz particles.

SECTION VI - HEALTH HAZARD INFORMATION:

ROUTES OF ENTRY: Inhalation: Yes; Skin: No; Ingestion: No

HEALTH HAZARDS: (Acute and Chronic) Excessive inhalation of dust may result in respiratory disease, including silicosis, pneumoconiosis and pulmonary fibrosis. Acute or rapidly developing silicosis may occur in a short period of time in heavy exposure in certain occupations such as sandblasters. Silicosis is a form of disabling pulmonary fibrosis which can be progressive and may lead to death. Be sure to maintain current physicals. The International Agency of Research on Cancer (IARC) has evaluated in Volume 42, Monographs on the Evaluation of the Carcinogenicity Risk of Chemicals to Humans, Silica and Some Silicates (1987), that there is "sufficient evidence for the carcinogenicity of crystalline silica to experimental animals" and "limited evidence" with respect to humans.

SIGNS AND SYMPTOMS OF OVEREXPOSURE:

INHALED: Undue breathlessness, coughing, sputum production, and reduced pulmonary function.

CONTACT WITH SKIN OR EYES: Irritation.

ABSORPTION THROUGH SKIN: Not Applicable.

SWALLOWED: May cause nausea.

CARCINOGENICITY:

NPT: No

IARC MONOGRAPHS: Yes - Level 2A Grouping.

OSHA REGULATED: Not as a carcinogen.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:

Individuals with pulmonary or respiratory disease such as asthma, bronchitis and emphysema should avoid prolonged exposure of silica dust. Pulmonary functions may be reduced by inhalation of respirable crystalline silica. Also lung scarring produced by such inhalation may lead to a massive fibrosis of the lung which may aggravate other pulmonary conditions and diseases and which increases susceptibility to pulmonary tuberculosis. Massive fibrosis may be accompanied by the right heart enlargement, heart failure, and pulmonary failure. Smoking aggravates the effects of exposure.

EMERGENCY FIRST AID PROCEDURES: For sand in eyes, wash immediately with water. If irritation persists, seek medical attention. For inhalation, remove person to fresh air, give artifical respiration as needed, seek medical attention as needed. If swallowed, do not induce vomiting. Vomiting may be fatal if breathed into lungs. Seek medical attention.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:
Use dustless methods (vacuum) and place into closable container for disposal, or flush with water. Do not dry sweep. Wear protective equipment. Avoid generating airborne respirable dust.

WASTE DISPOSAL METHOD: If uncontaminated, dispose as an inert, non-metallic mineral. If contaminated, use appropriate method in accordance with Federal, State and Local laws.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING: Avoid spillage. Use dustless systems for handling and employ engineering controls to reduce concentration of airborne dust.

OTHER PRECAUTIONS: Use dustless systems for handling, storage, and cleanup so that airborne dust does not exceed the PEL. Use adequate ventilation and dust collection. Do not permit dust to collect on walls, floors, sills, ledges, machinery, or equipment. Maintain good housekeeping. Maintain, clean, and fit test respirators in accordance with OSHA regulations. Maintain and test ventilation and dust collection equipment. Wash or vacuum clothing which has become dusty. We recommend that smoking be prohibited in all areas where respirators must be used.

WARN YOUR EMPLOYEES (AND YOUR CUSTOMER-USERS IN CASE OF RE-SALE) BY POSTING AND OTHER MEANS OF THE HAZARD AND OSHA PRECAUTIONS TO BE USED. PROVIDE TRAINING FOR YOUR EMPLOYEES ABOUT THE OSHA PRECAUTIONS.

See OSHA Hazard Communications Rule 29 CFR Sections 1910.1200, 1915.99, 1917.28, 1918.90, 1926.59, and 1928.21, and State and Local Worker of Community "Right to Know" laws and regulations.
See American Society for Testing and Materials (ASTM) standard practice E1132.86, "Standard Practice for Health Requirements Relating to Occupational Exposure to Quartz Dust."

See the most recent standards of the American National Standard Institute (ANSI Z.88.2), and the Mine Safety and Health Administration (MSHA) (30 CFR Part 56).

SECTION VIII - CONTROL MEASURES

RESPIRATORY PROTECTION (type): Use conventional particulate respiratory protection based on consideration of airborn concentrations and duration of exposure. See most recent standards of the American National Standard Institute (ANSI Z.88.2), the Occupational Safety and Health Administration (OSHA)(29 CFR Part 1910.134) and the Mine Safety and Health Administration (MSHA) (30 CFR Part 56). Use NIOSH or MSHA approved respiratory protection for respirable quartz under appropriate OSHA standards and regulations. Supplied air types recommended.

VENTILATION AND ENGINEERING CONTROLS:

Use sufficient local exhaust to reduce the level of respirable crystalline silica to the PEL. See ACGIH "Industrial Ventilation - A Manual of Recommended Practice" the latest edition.

EYE PROTECTION (type): Wear protective safety glasses at all time.

PROTECTIVE GLOVES: When exposed to hot product.

OTHER CLOTHING & EQUIPMENT: Provide eye wash. Monitor resirable quartz levels in workplace regularly.

WORK PRACTICES, HYGIENIC PRACTICES: Minimize dust generation. Clean up spills promptly. Train all employees on handling product before they work with it.

OTHER HANDLING AND STORAGE REQUIREMENTS: Protect containers from physical damage. Handle with minimum dust generation. Do not reuse containers.

SECTION IX - TRANSPORTATION

DOT HAZARD CLASSIFICATION: None
PLACARD REQUIRED: None
LABEL REQUIRED: Label as required by the OSHA Hazard Communication standard [29 CFR - 1910.1200 (f)], and applicable state and local regulations.

This form has been completed to meet all current state and federal (OSHA) regulations, but is offered without guarantee. Our company expressly disclaims all applications beyond our control. The data in this material safety data sheet relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process. The information set forth herein is based on technical data that Colorado Silica Sand, Inc. believes reliable. It is intended for use by persons having technical skills and at their own discretion and risk. Since conditions of use are outside our control, we make no warranties, expressed or implied, and assume no liability in connection with any use of this information. Nothing herein is to be taken as a license to operate under or a recommendation to infringe any patents. Any use of this data and information must be determined by the user to be in accordance with federal, state, and local laws and regulations. Customers and users of silica must comply with all applicable health and safety laws, regulations, and orders.

COLORADO SILICA SAND, INC.
ATTACHMENT "A"
COLORADO SANDS

FRAC SAND & WATER WELL GRAVEL PACK

4-6
4-8
6-9
8-12
8-14
8-16
10-20
16-30
16-40
20-40
32-42
40-60
100 Mesh

OIL WELL GRAVEL PACK

4-8
6-9
8-12
10-14
10-16
10-20
12-18
14-20
16-20
16-30
20-30
20-40
30-40
40-60

BLAST SAND GRIT

10
16
20
30
70

STUCCO SAND
FINES BLEND
FOUNDRY SAND
FILTER MEDIA SAND
PIPELINE SAND
ENGINE SAND
TOP DRESSING
SAND TRAP I
SAND TRAP II
SAND TRAP III
MARK IV

TEXAS RESCREENED SANDS

6-9
8-12
8-16
16-20
16-30
20-30

ALL MATERIALS SOLD BY COLORADO SILICA SAND, INC. INCLUDING BUT NOT LIMITED TO THE PRODUCTS NAMED ABOVE.