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Environmental Protection Department

Environmental Restoration Division

SEP 14
OSTI

Site Safety Plan
for
Lawrence Livermore National Laboratory CERCLA Investigations

July 1993

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Site Safety Plan

for

Lawrence Livermore National Laboratory

CERCLA Investigations

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Foreward

This Site Safety Plan for the Environmental Restoration Division's environmental investigations has been prepared specifically for the Lawrence Livermore National Laboratory (LLNL) Site in Livermore, California, on the basis of available data. This Health and Safety Plan was written to comply with applicable requirements of Occupational Safety and Health Administration regulations, including 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response. This document is intended as a general health and safety plan for LLNL and will be supplemented by Operational Safety Procedures for activities which are not sufficiently covered by this plan. As additional facts, monitoring data, or analytical data on hazards become available, this Plan will be modified. It is the responsibility of the co-Site Safety Officers (SSOs) to evaluate data that may impact health and safety during these activities and to modify the Plan as appropriate. Either of the co-SSO shall have the authority to institute any change that provides greater health and safety protection for workers at the LLNL Site.

1. Emergency Contacts and Telephone Numbers

This list needs to be updated as necessary to reflect current personnel, telephone numbers, positions and any other outdated information.

Local Contacts for All Emergencies

From Lawrence Livermore National Laboratory (LLNL) phones	***911***
Offsite Emergency Response	**911**

Hazardous Materials Information

Toxline	(301) 496-1131
CHEMTREC (24-hour, emergency only)	(800) 424-9300
ORNL, Toxicology Information Response Center	(615) 576-1743

LLNL Contacts

John P. Ziagos, Project Leader	(510) 422-5479
Gerald Duarte, Co-Site Safety Officer	(510) 423-2638
Beeper	(510) 423-7705-3180
Robert W. Bainer, Co-Site Safety Officer	(510) 422-4635
Beeper	(510) 423-7705-5554

Contractor Contacts

Michael Dresen, Senior Project Hydrogeologist, Weiss Assoc. (510) 547-5420

Standard Procedures for Reporting Emergencies

When calling **911** for assistance in an emergency situation, the following information should be provided:

1. Name of person making call.
2. Telephone number and location of person making call.
3. Name of person(s) exposed or injured and location.
4. Nature of emergency and type of exposure, when appropriate.
5. Actions already taken.

Never hang up first when calling for emergency assistance. Wait for the dispatch operator to finish all questions.

2. General Information and Policies

The safety policy of LLNL is to take every reasonable precaution in the performance of work to protect the environment and the health and safety of employees and the public, and to prevent property damage. With respect to hazardous agents, this protection is provided by limiting human exposures, releases to the environment, and contamination of property to levels that are as low as reasonably achievable (ALARA). It is the intent of this Plan to supply the broad outline for completing environmental investigations within ALARA guidelines. It may not be possible to determine actual working conditions in advance of the work; therefore, planning must allow the opportunity to provide a range of protection based upon actual working conditions. Requirements will be the least restrictive possible for a given set of circumstances, such that work can be completed in an efficient and timely fashion.

Due to the relatively large size of the LLNL Site and the different types of activities underway, site-specific Operational Safety Procedures (OSPs) will be prepared to supplement activities not covered by this Plan. Although the LLNL Site is one operable unit for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) compliance, Occupational Safety and Health Administration (OSHA) compliance would be more readily implemented by developing OSPs for each activity not covered by this Plan. These site-specific OSPs provide the detailed information for each specific activity and act as an addendum to this Plan, which provides the general plan for LLNL Main Site operation.

Employees working at LLNL must follow the policies set forth in this Plan, as well as LLNL and the U.S. Department of Energy (DOE) policies, procedures, and instructions. Of special value are the *LLNL Health and Safety Manual* (Hazards Control Department, 1989) and support provided by the LLNL Hazards Control Safety Team. Subcontractors must develop their own health and safety procedures, which may be modeled on those provided by LLNL. These procedures must be reviewed and approved by the Site Safety Officer (SSO), or a designee, prior to the initiation of work.

Each time the term SSO or co-SSO is used, either the co-SSO or a designee should take responsibility or complete the action.

Employees are encouraged to bring to the attention of their supervisor any unsafe or hazardous condition that they observe as they carry out their responsibilities. The supervisor

shall then inform the SSO promptly so that the situation can be corrected and personnel can be advised of an improved procedure. It is clearly impossible to anticipate all specific safety and health hazards beforehand; therefore, all personnel must exercise common sense and good judgment in their approach to a given situation.

The Health and Safety Training described in Section 9 of this document will assist in preparing individuals to recognize hazards. This document incorporates appropriate rules, guidelines, and recommended work practices contained in previously published material. All personnel potentially exposed to physical or chemical hazards as described in this Plan shall follow the safety and health procedures set forth herein.

Any modifications to this Plan will be issued as attachments to this document.

3. Summary of Background Information

LLNL is located about 40 miles east of San Francisco, California, in the Livermore Valley of eastern Alameda County approximately 3 miles east of Livermore. LLNL is operated by the University of California for the DOE. The Laboratory was established in 1952 to conduct nuclear weapon and other research. LLNL also carries out a variety of project work for other Federal and State agencies. In the 1940s, the Livermore Air Station was operated on the LLNL Site by the U.S. Navy.

The DOE is required to maintain an environmental protection program and has implemented the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) through DOE Order 5480.14. Under Environmental Protection Agency (EPA) oversight, the responsibility for conducting the remedial investigation and feasibility study of the LLNL Site is vested in the LLNL Ground Water Project, which is part of LLNL's Environmental Protection Department, Environmental Restoration Division (ERD).

During installation assessment of the LLNL Site, five areas were identified as CERCLA hazardous waste disposal sites as defined in DOE Order No. 5480.14. The five areas are: (1) the southwest quadrant of the Laboratory and offsite area to the west, (2) the gasoline spill area near the former Building 403, (3) the southeast section, (4) the east-central section, and (5) the remainder of site area, which includes all areas not in areas 1 through 4. These areas are now combined in a single operable unit for CERCLA compliance.

In 1983, LLNL began a ground water study beneath the LLNL Site and vicinity. Initial findings from that study indicated that volatile organic compounds (VOCs) were present in ground water. Ongoing investigations have indicated the presence of a variety of substances in ground water and soil. On the basis of analytical results, the substances present in concentrations greater than California Department of Toxic Substances Control (DTSC) or EPA Action Levels include:

- Trichloroethylene (TCE).
- Tetrachloroethylene (PCE).
- Carbon tetrachloride (CCl_4).
- 1,1-Dichloroethane (1,1-DCA).
- 1,2-Dichloroethane (1,2-DCA).
- 1,2-Dichloroethylene (1,2-DCE).
- Chloroform.
- 1,1-Dichloroethylene (1,1-DCE).
- Tritium.

Sampling results have shown several locations with VOCs in ground water in the part-per-billion (ppb) range and several areas where concentrations greater than 1 part per million (ppm) were detected. In one area, one well contains tritium above the drinking water standard of 20,000 pCi/L.

Results of Ground Water Project chemical analyses for the Gasoline Spill Area also identified the presence of:

- Benzene.
- 1,2-Dichloroethane (1,2-DCA).
- Xylene isomers.
- Total fuel hydrocarbons (TFH).

- Toluene.
- Ethlyene dibromide (EDB).

Other work activities may pose potential exposures or problems due to:

- Heat stress.
- Noise.
- Nuisance dust.
- Heavy equipment.
- Confined space entry.
- Electrical hazards.

This plan addresses health and safety issues related to the various tasks and phases for the environmental work planned and ongoing at LLNL. Technical issues and specifications for the scope of work are presented in the specific LLNL quality assurance, work, and closure plans and in the Standard Operating Procedures manual. Copies of the specific LLNL Quality Assurance Plan, and closure plans, as well as The Standard Operating Procedures manual referred to in the *LLNL Health and Safety Manual* are available for ready reference in the ERD office. The SSO should review these documents in order to correctly carry out assigned responsibilities and to assist in presenting pertinent health and safety concerns to site workers.

4. Organization, Responsibilities, and Authority

Key personnel are listed below by name, title, address, and telephone number.

William M. McConachie
LLNL Ground Water Division Leader
L-619, P.O. Box 808
Lawrence Livermore National Laboratory
Livermore, CA 94551
(510) 423-3501

John P. Ziagos
LLNL Ground Water Project Leader
L-619, P.O. Box 808
Lawrence Livermore National Laboratory
Livermore, CA 94551
(510) 422-5479

Gerald Duarte
Co-Site Safety Officer
L-619, P.O. Box 808
Lawrence Livermore National Laboratory
Livermore, CA 94551
(510) 423-2638

Robert W. Bainer
Co-Site Safety Officer
L-619, P.O. Box 808
Lawrence Livermore National Laboratory
Livermore, CA 94551
(510) 422-4635

The ERD Leader has ultimate authority over the overall operations of the site. He approves changes in the scope of the operations, contractors bids, schedules, etc.

The LLNL Ground Water Project Leader has ultimate authority over the overall operation of the site in the absence of the ERD Leader. He also has the responsibility to ensure that all operations are conducted by the SSO's in accordance with this Site Safety Plan.

Health and safety activities are important during all phases of any project. The degree of implementation of the activities or services is related to the perceived risk. The SSO shall have the responsibility to determine health and safety needs for this project and the authority to ensure that appropriate measures are taken. All site personnel shall comply with the requirements of this plan and cooperate with project management in its implementation. It is the responsibility of all site personnel to immediately report any of the following to the SSO:

A. All accidents or injuries.

B. Unsafe or malfunctioning equipment.

C. Any symptoms or signs of chemical exposure.

D. Unexpected or uncontrolled releases of chemicals.

E. Unauthorized personnel entry onto the site.

F. Any changes in the site conditions which might adversely affect the health and safety of personnel.

The SSO shall immediately inform the Project Leader, John P. Ziagos (510) 422-5497, of any health and safety conditions that may adversely affect the project.

The SSO, or a designee, has the authority to:

- Obtain information and assistance from Hazards Control Safety Team Four or other appropriate support as warranted.
- Require specific health and safety precautions prior to work site entry by LLNL and contractor personnel, and ensure that personnel adhere to requirements of this Plan.
- Require any LLNL or contractor employee to obtain immediate medical attention in case of an injury or illness.
- Deny LLNL and/or contractor personnel access to any LLNL work site.
- Establish an area in the support zone upwind of the work zone where personnel are to gather if there is an evacuation from the work zone.
- Order the immediate evacuation of LLNL and/or subcontractor employees from any work site when hazardous conditions arise in the course of work.
- Permit visitors (i.e., anyone other than an LLNL or contractor employee) at work sites only at the direction of, and with the permission of, responsible LLNL personnel. Visitors shall abide by the requirements specified in this Plan and, when possible, shall be restricted from areas of potential exposure to hazardous substances.
- Monitor LLNL and contractor operations for the existence of hazardous conditions, and monitor personnel for signs of exposure, heat stress, fatigue, etc.
- Evaluate results of the monitoring program and determine its impact on future operations.
- Ensure that environmental and personnel monitoring operations are ongoing and carried out in accordance with technical specifications, procedures, and project instructions.
- Monitor site conditions during operations to determine whether any changes in work zones or personnel protection are required.
- Ensure that proper personal protective equipment (PPE) is are available and worn by onsite personnel, and ensure that PPE and other equipment are maintained and properly stored.
- Ensure that work areas are kept clean and orderly to control potential general safety hazards.
- Know the emergency procedures and contacts.

The SSO will review and update the Plan every 3 years or as necessary to ensure that the listed organizational structure reflects the current status of the site operations. The review will reflect changes in technology, operation, contamination, etc. The SSO will also conduct work site safety briefings to cover the contents of this Plan, safe work practices, PPE use, and emergency procedures.

All LLNL and subcontractor personnel assigned to this project are responsible for following this Plan, using safe work practices, and wearing the PPE specified by the SSO. The SSO shall inform all subcontractors of emergency response procedures and known hazards of the operations prior to site entry. Project personnel shall report hazards and unsafe conditions and practices to the SSO. Project personnel must comply with all Federal, State, and local health and safety regulations.

This Plan and supporting health and safety documents must be available for review and use by the SSO, cognizant regulatory agencies, and all project personnel.

The Team Leader of Environmental Safety and Health (ES&H) Team 4 (Hazards Control Department) provides an interface between the members of Team 4 and ERD. The health and safety professionals and technicians assigned to Team 4 provide support and technical services to the SSO or a designate as requested and required by LLNL policy.

5. Medical Screening Program

The purpose of the medical screening program is to assess the health status of personnel prior to work, monitor personnel for evidence of postproject adverse health effects, and determine the suitability of individuals for future work assignments of this type. All personnel who will be working on this project must undergo a medical evaluation before participating in these operations. If the SSO determines that significant exposure to hazardous materials is encountered in these operations, a follow-up medical exam shall be conducted on the exposed individuals.

Baseline and periodic health assessments for project personnel shall be consistent with LLNL requirements and OSHA regulations prescribed in 29 CFR 1910, especially those in 1910.120, *Hazardous Waste Operations and Emergency Response*.

At a minimum, the examination should include:

- Medical and organizational histories.
- Physical examination.
- Vision test.
- Urinalysis.
- Blood chemistry panel and complete blood count.
- Pulmonary function tests and respirator use clearance.

Optional tests include:

- X-rays.
- Electrocardiograms.
- Bioassays for specific compounds, if recommended by the examining physician due to previous or expected exposures.

Due to the low risk of acute exposure, additional medical monitoring specific to this project is not anticipated.

If an individual has completed an occupational medical exam within the past 12 months, the *examining physician* may determine that another complete exam is unnecessary.

In addition to the medical screening program, a medical surveillance program will be provided by the LLNL ERD for its employees when one or more of the following items are applicable:

A. All employees who are or may be exposed to airborne levels of hazardous substances above OSHA Permissible Exposure Limits (PEL) or, in the absence of PEL, other published exposure limits, without regard to the use of respirators, for 30 days or more per year.

B. All those who use a respirator for 30 or more days per year or are required to do so under 29 CFR 1910.134 Respiratory Protection.

C. All employees who are injured due to overexposure from an emergency incident involving hazardous substances or health hazards.

Employees covered by the medical surveillance program will be given medical examinations and consultations at the following frequency:

A. Prior to assignment.

B. Annually unless attending physician extends the interval up to 2 years or decreases the interval as medically necessary.

C. At termination of employment or reassignment to another area where employee will not be under medical surveillance if the employee has not had an examination within the last 6 months.

D. As soon as possible after development of signs or symptoms indicating overexposure to hazardous substances above PEL or other published exposure levels in an emergency situation.

Medical examinations will include a medical and work history (or updated history if one is in the employee's file) with special emphasis on: symptoms related to the handling of hazardous substances, health hazards of these substances, and fitness for duty, including the ability to wear any required PPE under the conditions (i.e., temperature extremes) that may be expected at the work site. All medical examinations and procedures shall be performed by or under the supervision of a licensed physician.

The attending physician will be provided with the following information by the site safety officer or supervisor in conjunction with Hazards Control:

A. A description of the employee's duties as they relate to employee's exposures.

B. The employee's exposure levels or anticipated exposure levels.

C. A description of any personal protective equipment used or to be used. If respirators are to be worn, then information will be provided concerning the type, anticipated periods of use, workloads, etc., as required by 29 CFR 1910.134.

D. Where feasible, information from previous medical examinations of the employee which is not readily available to the examining physician.

E. A copy of this standard and its appendices.

LLNL Health Services will provide each covered employee with a written opinion from the attending physician containing the following:

A. A summary of the results of the examination.

B. An opinion as to whether the employee has any detected medical conditions which would place the employee at increased risk of impairment of the employee's health from work in hazardous waste site operations or from the use of respirators. The written opinion shall not reveal specific findings or diagnoses unrelated to occupational exposure.

C. Any recommended limitations upon the employee's assigned work.

D. Any medical conditions which require further medical examination or treatment.

An accurate record of the medical surveillance required by this standard shall be retained in accordance with 29 CFR 1910.20. The record shall include at least the following items:

A. Employee's name and social security number.

B. Physician's written opinion, recommended limitations, and results of examinations and tests.

C. Any employee medical complaints related to exposure to hazardous substances.

D. A copy of the information provided to the examining physician by the employer with the exception of the standard and its appendices.

Employees who may be exposed to chemical hazards while performing project work must receive medical screening. LLNL will screen at-risk LLNL employees, and contract firms will screen their at-risk employees, as specified in their contracts with LLNL and DOE.

6. Hazard Evaluation

The potential hazards associated with the environmental investigations and clean up of the LLNL Site include:

Chemical hazards

- Trichloroethylene (TCE).
- Tetrachloroethylene (PCE).
- Carbon tetrachloride (CCl_4).
- 1,1-Dichlorethane (1,1-DCA).
- 1,2-Dichloroethane (1,2-DCA).
- 1,2-Dichloroethylene (1,2-DCE).
- Chloroform.
- 1,1-Dichloroethylene (1,1-DCE).
- Tritium.
- Benzene.
- Toluene.
- Xylenes.
- Gasoline and diesel fuel.

Physical hazards

- Heavy equipment (drill rig, backhoe, crane).
- Noise.
- Heat stress.
- Excavations.
- Underground utilities.
- Fire and explosion.
- Electrical.
- Confined space.

General Safety Hazards

Hazards to Nonproject Personnel

These particular hazards have been identified from existing knowledge of site conditions and prior site activities, and represent likely or potential hazards to site personnel during the environmental investigations. It is possible, however, that unforeseen hazards could be encountered during site work. In the event that any such encounter occurs, work should cease and the SSO should be informed as soon as possible so that the situation can be evaluated and appropriate steps can be taken by the SSO to address the safe resumption of work.

6.1. Chemical Hazards

Because analytical and operational monitoring data demonstrate negligible or very low concentrations for many VOCs, this evaluation has been restricted to a consideration of benzene, carbon tetrachloride, chloroform, 1,1-DCA, 1,2-DCA, 1,1-DCE, 1,2-DCE, diesel, gasoline, PCE, TCE, tritium, toluene, and xylenes. These chemicals may enter the body through inhalation, ingestion, or skin absorption. They may enter by more than one route, may cause damage at the point of entry, or may cause organ damage after being metabolized. During project activities, ingestion is unlikely. Pertinent data are summarized below.

6.1.1. Benzene

Odor	Aromatic odor.
Odor threshold	Approximately 4.7 ppm.
Fire potential	Dangerous; when exposed to heat or flame, can react vigorously with oxidizing materials.

Flammable limits	Lower Flammable Limit (LFL) 1.3%, Upper Flammable Limit (UFL) 7.9%.
Explosive limits	Lower Explosive (LEL) 1.3%, Upper Explosive Limit (UEL) 7.1%.
Exposure	Irritating to eyes, nose, and throat at high concentrations. Prolonged exposure may affect the blood-forming system. Symptoms: nervous excitation and giddiness followed by depression, drowsiness, or fatigue, and a tightness in the chest.
OSHA PEL	Time-Weighted Average (TWA) 1 ppm; Short-term Exposure Limit (STEL) 5 ppm.
ACGIH TLV	TWA 10 ppm; a suspected human carcinogen.
NIOSH	TWA 0.1 ppm; Ceiling Exposure Limit (CEIL) 1 ppm; a human carcinogen (leukemia).
IDLH	2,000 ppm.

6.1.2. Carbon tetrachloride (CCl_4)

Odor	Heavy, ether-like odor.
Odor threshold	50 ppm.
Fire potential	Not combustible.
Exposure	Primarily a narcotic, but prolonged exposure can cause liver and kidney damage. Symptoms: drowsiness, dizziness, and incoordination.
OSHA PEL	TWA 10 ppm; CEIL 25 ppm; maximum peak (PEAK) 200 ppm, 5 minutes in any 4 hours (transitional limits). TWA 2 ppm (final limit).
ACGIH TLV	TWA 5 ppm; skin; a suspected human carcinogen.
NIOSH	CEIL 2 ppm; a human carcinogen (liver).
IDLH	300 ppm.

6.1.3. Chloroform

Odor	Pleasant; ether-like; nonirritating.
Odor threshold	50 to 200 ppm.
Fire potential	Nonflammable, but will burn on prolonged exposure to flame or high temperature.
Exposure	Irritating to eyes, nose, and throat. Symptoms: headache, dizziness, drunkenness, and narcosis.
OSHA PEL	STEL 50 ppm (transitional limit); TWA 2 ppm (final limit)
ACGIH TLV	TWA 10 ppm; a suspected human carcinogen.
NIOSH	CEIL 2 ppm; a suspected human carcinogen.
IDLH	1,000 ppm.

6.1.4. 1,1-DCA

Odor	Aromatic, ether-like odor.
Odor threshold	88-200 ppm.
Fire potential	Very volatile flammable liquid.
Flammable limits	LFL 5.9%, UFL 15.9%.

Explosive limits	LEL 5.6%, UEL 11.4%.
Exposure	A narcotic and can also cause damage to liver, kidneys, and lungs. Symptoms: drowsiness.
OSHA	TWA 100 ppm.
ACGIH TLV	TWA 200 ppm; STEL 250 ppm.
IDLH	4000 ppm.

6.1.5. 1,2-DCA

Odor	Mild, sweet odor resembling that of chloroform.
Odor Threshold	50 ppm.
Fire Potential	Very volatile flammable liquid.
Flammable limits	LFL 6.2%, UFL 15.9%.
Explosive limits	LEL 6.2%, UEL 16%.
Exposure	Irritating to eyes, nose, and throat. Symptoms: nausea, dizziness, and vomiting.
OSHA PEL	TWA 50 ppm; CEIL 100 ppm; PEAK 200 ppm, 5 minutes in any 3 hours.
ACGIH TLV	TWA 10 ppm.
NIOSH	TWA 1 ppm; CEIL 2 ppm; a suspected human carcinogen.
IDLH	1,000 ppm.

6.1.6. 1,1-DCE

Odor	Mild, sweet odor resembling that of chloroform.
Odor threshold	500 to 1,000 ppm.
Fire potential	Very volatile flammable liquid.
Flammable limits	LFL 7.3%, UFL 16%.
Explosive limits	LEL 5.6%, UEL 11.4%.
Exposure	Irritating to eyes, nose, and throat. Symptoms: nausea, dizziness, and drunkenness.
OSHA	TWA 1 ppm (final limit).
ACGIH TLV	TWA 5 ppm; STEL 20 ppm.

6.1.7. 1,2-DCE

Odor	Ether-like, slightly acrid odor.
Odor threshold	0.1 ppm.
Fire potential	Very volatile flammable liquid.
Flammable limits	LFL 9.7%, UFL 12.8%.
Exposure	Irritating to eyes, nose, and throat, and a narcotic. Symptoms: dizziness and drowsiness.
OSHA PEL	TWA 200 ppm.
ACGIH TLV	TWA 200 ppm.
IDLH	4,000 ppm.

6.1.8. Diesel

Odor	Characteristic of petroleum distillate.
Fire potential	Flash point 85°C; fire hazard greater if liquid temperature exceeds 85°F; may explode if pressure is used to empty drums.
Exposure	Irritating to eyes, nose, and throat; central nervous system depressant if inhaled; possible carcinogen. Symptoms: headache, dizziness, loss of appetite, weakness, and loss of coordination. Incomplete combustion produces carbon monoxide; toxic fumes may accumulate.
ACGIH TLV	Not established. Reduce exposure to lowest feasible level.

6.1.9. Gasoline

Odor	Characteristic of gasoline; threshold, 0.25 ppm.
Fire potential	Flammable; flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area.
Flammable limits	LFL 1.4%, UFL 7.4%.
Exposure	Irritating to eyes, nose, and throat. Symptoms: irritation of mucous membranes, dizziness, headache, incoordination, anesthesia, and coma.
ACGIH TLV:	TWA, 300 ppm; STEL, 500 ppm.

6.1.10. PCE

Odor	Chloroform-like odor.
Odor threshold	5 ppm.
Fire potential	Nonflammable.
Exposure	Irritating to eyes, nose, and throat. Symptoms: affects central nervous system, causes anesthesia.
OSHA PEL	TWA 100 ppm; CEIL 200 ppm; PEAK 300 ppm, 5 minutes in any 3 hours.
ACGIH TLV	TWA 50 ppm; STEL 200 ppm.
IDLH	500 ppm.

6.1.11. TCE

Odor	Chloroform-like odor.
Odor threshold	50 ppm.
Fire potential	Low fire hazard.
Flammable limits	LFL 8%, UFL 10.5%.
Explosive limits	LEL 12.5%, UEL 90%.
Exposure	Irritating to eyes, nose, and throat. Symptoms: nausea, blurred vision, and disturbance of central nervous system.
OSHA PEL	TWA 100 ppm; CEIL 200 ppm; PEAK 300 ppm, 5 minutes in any 2 hours (transitional limits). TWA 50 ppm; STEL 200 ppm (final limits).
ACGIH TLV	TWA 50 ppm; STEL 200 ppm.

NIOSH	TWA 25 ppm; a suspected human carcinogen.
IDLH	1,000 ppm.

6.1.12. Tritium (^3H)

Half-life: Physical: 12.3 years.
Biological: ~10 days (range: 4–18) total body for HTO.

Special Chemical and Biological Characteristics:

Not selectively concentrated in any organ. Metabolized as H_2O. Tritium is assumed to be readily and completely absorbed by the body and to be distributed evenly throughout the body.

Principal Human Metabolic and Dosimetric Parameters

$f_1 = 1.0$.
ALI (μCi) = 8.1 ¥ 10^4 (HTO).
DAC (μCi/cm^3)= 2.2 ¥ 10^7 (HTO).

6.1.13. Toluene

Odor	Sweet, pungent, benzene-like odor.
Odor threshold	0.17 to 2.1 ppm.
Fire potential	Flammable liquid ignitable under almost all normal temperature conditions.
Flammable limits	LFL 1.2%, UFL 7.1%.
Explosive limits	LEL 1.2%, UEL 7.1%.
Exposure	Irritating to eyes, nose, and throat. Symptoms: dizziness, headache, and anesthesia.
OSHA PEL	TWA 200 ppm; CEIL 300 ppm; PEAK 500 ppm, 10 minutes (transitional limits). TWA 100 ppm; STEL 150 ppm (final limits).
ACGIH TLV	TWA 100 ppm; STEL 150 ppm.
NIOSH	TWA 100 ppm; CEIL 200 ppm.
IDLH	2,000 ppm.

6.1.14. Xylenes

Odor	Like benzene.
Odor threshold	0.05 ppm.
Fire potential	Material is flammable and can form explosive mixtures with air.
Flammable limits	XLM: LFL 1.1%, UFL 6.4%. XLO: LFL 1.1%, UFL 7.0%. XLP: LFL 1.1%, UFL 6.6%.
Exposure	Irritating to eyes, nose, and throat. Symptoms: headache, dizziness, coughing, and pulmonary edema.
OSHA PEL	TWA 100 ppm (transitional and final limit). STEL 150 ppm (final limit).
ACGIH TLV	TWA 100 ppm; STEL 150 ppm.

NIOSH	TWA 100 ppm; CEIL 200 ppm.
IDLH	1,000 ppm.

Exposure limits, detectable limits, and other references to airborne chemical concentrations given are for vapors in air. Concentrations encountered in soil and ground water are several orders of magnitude lower than the specified limits. Therefore, even direct contact with soil and ground water in the field and exposure to associated vapors would not constitute acute exposures at high concentrations. Some operations may involve the use of hazardous substances which are not hazardous wastes, but are used in the operations or stored onsite. For example, hydrogen peroxide (50%), which is a strong oxidizer, is used on some sites to treat ground water contamination. The SSO and/or site supervisor will ensure that all site employee's are trained in accordance with 29 CFR 1910.1200, Hazard Communication, and the LLNL Health and Safety Manual Supplement 7.02 (formerly 1.02). The acronyms that describe exposure limits are defined in Appendix A. Material Safety Data Sheets (MSDS) for the compounds listed above are included in Appendix B.

6.1.15. Respiratory Hazards

The respiratory hazards associated with work activities are exposure to vapors, gases, or dusts during drilling, well installation, water sampling, tank excavation, decontamination, and other operations. It is not anticipated that exposure levels in excess of recommended PELs or TLVs will be encountered. Air monitoring will be conducted, as discussed in Section 8. The open-air environment at the site should provide adequate ventilation to reduce potential respiratory hazards to very low or negligible levels.

6.1.16. Dermal Hazards

Dermal hazards result from direct contact of solids, liquids, or vapors with the skin. Since the potential for vapor contact is low, dermal hazards from vapors are expected to be negligible. Direct contact with contaminated soil and ground water in the field would not generally result in dermal effects. However, good hygienic practices, and the fact that these chemicals may be absorbed through the skin, warrant protecting the skin.

Based upon previous experience at this and other sites, it is anticipated that direct skin contact is unlikely to occur if protective clothing and/or protective equipment is used.

6.2. Physical Hazards

Working conditions at the site involve potential exposure to the physical hazards discussed below.

6.2.1. Heavy Equipment

The hazards associated with heavy equipment, especially drilling rigs, primarily involve moving parts and exposure to possible pinch points. Safety protection, including equipment guards, will be provided to mitigate this problem. In addition, no loose hair will be allowed around the heavy equipment, and only qualified personnel will operate machinery. Hard hats and steel-toed boots will be worn by all personnel operating or working in proximity to heavy equipment. Refer to Appendix E for additional safety information concerning drilling rigs.

6.2.2. Noise

The site operations are monitored for detection of excessive noise levels. When a survey indicates that hearing protection is necessary, appropriate hearing protection devices will be provided to field personnel. The use of hearing protection is required in those high noise areas when excessive sound levels are present.

Noise exposure is primarily associated with heavy equipment, steam cleaning, and air compressors. Based upon previous experience, it is not anticipated that the noise levels will be of concern. Ear protection is provided for all field personnel, and its use is encouraged when appropriate for personnel comfort.

6.2.3. Heat Stress

Heat stress is associated with exposure to high temperatures, wearing protective clothing, and physical exertion. Temperatures at the site can exceed 100°F on occasion. Drinking water is available onsite, and appropriate breaks shall be taken if temperature and levels of personal protection so dictate. Based upon previous experience and work performed at this site, it is not anticipated that heat stress will be a major concern.

Personnel will inform the SSO of any symptoms of heat stress, such as:

- Weakness and fatigue.
- Dizziness.
- Nausea.
- Headache.

The SSO will be alert to signs of heat stress in site personnel and increase the frequency of breaks and fluid consumption as necessary.

6.2.4. Excavations

Open excavations are dangerous because personnel may fall into the excavation or the side walls may collapse while personnel are inside the excavation. To minimize these hazards, each excavation shall be barricaded as described in Section 10.2. Also, the excavation walls shall be properly sloped or shored before allowing anyone to enter the excavation. Personnel not directly involved in excavation activities or who do not need to be in the area will remain at least 10 feet away from the edge of the excavation. Work in or around excavations shall be carefully planned in consultation with the SSO regarding protective measures and equipment use. Additional information regarding necessary precautions and Cal/OSHA requirements is presented in Appendix C.

6.2.5. Confined Space Entry

Although no confined space entries are currently anticipated, employees will be trained in what types of areas might be confined spaces. When entry into a confined space is necessary, Hazards Control will be contacted to obtain a confined space entry permit. The procedures required by the LLNL Health and Safety Manual Supplement 26.14, "Working in Confined Spaces," and the 29 CFR 1910.146 Permit Required Confined Spaces will be followed.

6.2.6. Overhead Power Lines

No equipment shall be operated closer than 15 feet in any direction to overhead power lines. Operation closer than 15 feet may be permitted only when overhead power lines have been deenergized, locked, and tagged out.

6.2.7. Underground Utilities

Prior to any drilling or excavation all underground utilities will be located by licensed utility locators and/or LLNL Plant Operations personnel.

6.2.8. Fire and Explosion

It is not anticipated that ground water and soil contaminants exist at concentrations sufficient to create fire and explosion hazards during routine drilling and sampling activities. Removal of underground tanks could create a potential for fire and explosion hazards. [Refer to the LLNL Site Safety Plan for Tank Excavation and Removal of Underground Storage Tanks at Buildings 401, 402, and 411 (October 29, 1988) or information on the safety considerations associated with underground tank removal.]

Several chemicals that may be encountered at the site during tank excavation are highly flammable liquids, and they are explosion hazards if vapors are present at levels above the lower explosive limit (LEL).

Chemical Name	*LEL (% by volume in air)*
Benzene	1.3
Gasoline	1.4
Xylenes	1.0

To minimize explosion hazards, all tanks and piping will be emptied and flushed prior to excavation. All piping will be disconnected from tanks, the tanks emptied, and dry ice applied to the tank interior to displace oxygen prior to tank removal. The atmosphere inside the tank will be monitored with a combustible gas indicator prior to removal. At least one 20-pound dry chemical fire extinguisher will be available. No hot work or open flames will be allowed in the work area without the express authorization of the SSO and the Fire Department, and ensuring appropriate safety controls being implemented. It is anticipated that concentrations of these substances in fill or soil materials will be sufficiently low to present no fire hazard. However, the detection of fuel products in fill and soil materials shall be cause to initiate the evaluation for vapors with respect to fire, explosion, and personnel exposure.

6.2.9. Electrical Hazards

Ignorance of basic electrical principles and misuse of electrical equipment contribute to many accidents. The electrical resistance of the human body can be drastically reduced by working with wet tools, in wet or damp locations, inside tanks and boilers, or around metal piping or other grounding materials. Other factors that affect the severity of electrical

injuries include the path of the current through the body, the vital organs in that path, and the duration of the current through the body.

There are many ways an employee can come into contact with energized circuits. The most common way is contact with exposed live parts and overhead or buried power lines. When working in the vicinity of live electrical parts, such as exposed wires, switches, or contacts, the parts must be guarded from contact by effective insulation or other means. If that is not possible, the circuit must be de-energized and visibly grounded. Pertinent information on electrical safety can be found in Appendix D.

6.3. General Safety Hazards

Other possible safety hazards include the potential for slipping, falling, head trauma, lifting heavy objects, insect bites, etc. All personnel working on the project will wear appropriate PPE, including eye protection, head protection (hard hat), and steel-toed boots as required by the SSO. At a minimum, EPA Level D protection is required. First aid will be available onsite to take care of any minor injuries. Contact Emergency Response Dispatch (**911**) in emergency situations more serious than cuts or scrapes (offsite, dial **911**).

Contact Emergency Response Dispatch (911) in emergency situations more serious than cuts or scrapes.

6.4. Hazards to Nonproject Personnel

Potential risks to project personnel have been outlined above. Potential risks to other persons on the site, who are not working on this project, are exposure to vapors, gases,and chemicals in soil or ground water and the physical hazards associated with heavy equipment.

Air monitoring will be conducted to minimize the possibility of public and personnel exposure to vapors and gases. These procedures are described in Section 8. Due to the open-air environment at the site and the fact that the work zone will be barricaded, the risk to the public and LLNL personnel is expected to be negligible.

7. Emergency Actions

7.1. Planning

The SSO shall plan escape routes and discuss them with project personnel before they enter a site to begin work. Initial planning includes establishing the best means for evacuation from the site in case of a catastrophe (e.g., explosion, tank rupture, fire, etc.).

7.2. Emergency Services

A tested system must be in place for rapid and clear distress communications, preferably voice, from all personnel to the emergency response unit of the LLNL Fire Department and the SSO. The SSO shall ensure that all personnel working at the site know how to communicate with the LLNL Emergency Response Dispatch at **911** (Offsite, dial **911**). The SSO shall notify appropriate local emergency response units, and provide adequate and clear directions to reach LLNL work sites from the location of those units before beginning any onsite investigations or operations. All personnel shall have adequate and clear directions and access to personnel transportation (e.g., keys in ignition) to local emergency services.

7.3. Evacuation

If evacuation is necessary, all personnel will proceed to a predetermined location in the support zone upwind of the work zone.

The predetermined evacuation route and assembly location will be specified at each site. ERD employees and subcontractors will evacuate the worksite and not directly assist in handling the emergency.

The signal for evacuation will be three short blasts in succession on an air or car horn.

7.4. Emergency Evacuation From Contaminated Areas

Any person requiring medical attention shall be evacuated promptly from any contaminated area. However, personnel shall not enter an area to attempt a rescue if their own lives would also be threatened because of inadequate personal protection (e.g., oxygen-deficient atmosphere and no self-contained breathing apparatus). Contact the LLNL Emergency Response Dispatch at **911** to evacuate any person from any area of the site if necessary and to provide special decontamination treatment or procedures for any injured person. The SSO shall order evacuation of any person whose PPE fails.

Contact Emergency Response Dispatch at 911 for evacuation or decontamination treatment or procedures (from offsite, dial 911).

7.5. First Aid

Qualified personnel shall give first aid and stabilize any employee needing assistance. Life support techniques such as CPR and treatment of life-threatening problems, such as bleeding, airway maintenance, and shock, shall be given top priority. Professional medical assistance shall be obtained at the earliest possible opportunity. If assistance beyond first aid is required, phone the LLNL Emergency Response Dispatch at **911**.

Maintain a first aid kit and portable eyewash in the support zone. When drilling, these items should be kept in a clean location near or on the drill rig.

Emergency first aid procedures for organic compounds.

Exposure	Procedures
Eyes	Flush eyes immediately with fresh water for at least 15 minutes while holding the eyelids open. Call LLNL Emergency Response Dispatch at 911 immediately.
Skin	Wash skin thoroughly with soap and water. See a doctor if any unusual signs or symptoms or if any skin irritation occurs. Launder contaminated clothing.
Inhalation	Move exposed person to fresh air. If breathing has stopped, apply artificial respiration. Call LLNL Emergency Response Dispatch at 911 immediately.
Ingestion	If swallowed, DO NOT make person vomit. Call LLNL Emergency Response Dispatch at 911 immediately.

7.6. Fire

Call the LLNL Fire Department at **911** in the event of any fire.

7.7. Hazardous Materials Spill

For spills greater in volume than one gallon, call LLNL Emergency Response Dispatch at **911**. Refer to the appropriate MSDS (see Appendix B) for special instructions regarding cleanup or spills.

7.8. Guidelines

If any emergency involving actual or suspected personal injury occurs, the SSO, work supervisor, and surviving personnel shall follow these steps:

- Remove the exposed or injured person(s) from immediate danger.
- Render first aid if necessary. Decontaminate affected personnel at the LLNL Medical Facility, Building 663.
- Obtain paramedic service or ambulance transport to local hospital by calling the LLNL Emergency Response Dispatch at **911**. This procedure shall be followed even if there is no visible injury.
- Other personnel onsite shall be evacuated to a safe distance until the Fire Department determines that it is safe for work to resume.
- At the earliest time practicable, the SSO shall contact the Project Leader or a designee and Hazards Control, giving details of the incident and the steps taken to prevent its recurrence.
- A written report of the incident must be forwarded to the Project Leader or a designee within 24 hours following the incident.

Subsequent reporting shall be completed according to the requirements of the *LLNL Health and Safety Manual*, Section 4: Incident Analysis and Reporting.

8. Personal Protective Apparel and Equipment

Suggested item specifications and descriptions in this section are for information only. Equivalent items may be purchased.

8.1. Personnel Protection

The nature of this work is such that several potentially hazardous conditions could be encountered. It is not possible to determine in advance of actual conditions all protective requirements. Items specified below are intended to allow the SSO the latitude to provide a range of protection based upon actual working conditions. Where feasible, engineering controls in accordance with 29 CFR 1910, Subpart G and work practices are used to prevent exposure of employees to hazardous substances above their PEL or other published exposure limit if no PEL exists. However, when such is not feasible or not required, a reasonable combination of engineering controls, work practices, and PPE will be used. PPE selection is made to protect the employees from hazards or potential hazards at the site in accordance with 29 CFR 1910, Subpart I, Personal Protective Equipment.

The proper use and selection of PPE include consideration of at least the following items:

A. Proper usage procedure (i.e., donning and doffing).

B. Equipment limitations (i.e., reduced dexterity, vapor versus liquid contact, hazardous substance and concentration, and temperature).

C. Anticipated duration of use.

D. Maintenance and storage requirements.

E. Decontamination and disposal.

F. Inspection procedures.

G. Heat and cold stress, activity levels, and other medical consideration.s.

H. Employee training and fitting of equipment.

The use of employee rotation in order to achieve compliance of employee exposures to hazardous substances with PEL's is not anticipated and would only be used when no other feasible means is available (i.e., a reasonable combination of engineering controls, work practices, PPE, etc.).

At a minimum, EPA Level D protection shall be worn during investigations at the Livermore Site. It is not expected that higher levels of protection would be required often.

Depending upon the circumstances and the hazards present at a given site, the level of PPE will be determined by Hazards Control Team 4. Some of the items recommended for a given level may be modified as appropriate (see Appendix G). The level of protection is selected based primarily upon:

A. Characteristics of hazardous substances (i.e., toxicity, concentration, entry routes, warning properties, etc.).

B. The potential for exposure in air, from splashes or from immersion in liquids, or other direct contact with hazardous substances.

Level D consists of a work uniform which provides minimal protection and essentially no protection against chemical hazards. It is used when no inhalation hazard is present nor anticipated to occur during the operations and skin contact with hazardous substances by immersion or splashes is not anticipated.

Many of the following items are only necessary for upgrading to Modified Level C protection. However, the SSO or a designee shall ensure that all workers have all the following items available for their use:

- **Gloves**

  Inner, surgical type (vinyl disposable)
  Outer, chemical protective (neoprene or nitrile)

- **Protective clothing**

  Cotton, regular, washable coveralls
  AND Tyvek, regular, disposable, zippered coveralls

- **Footwear**

  Chemical protective boots (low-temperature vinyl), steel-toed
  OR safety shoes worn with protective rubber overshoes

- **Eye protection**

  Safety glasses with optional side-shields
  OR goggles
  OR single unit plastic "specs" with side-shields

- **Hard hat with attachable face shield (optional)**

- **Hearing protection**

  Muffs and/or earplugs

- **Respirators**

  National Institue for Occupational Safety and Health (NIOSH) approved full face mask air-purifying respirator equipped with a high-efficiency particulate filter (HEPA) with protection for organic vapors, acid gases, dusts, fumes, and mists, asbestos, and radionuclides. The protection for dusts, fumes, and mists shall be furnished for a TWA less than 0.05 mg/m^3.

  OR NIOSH-approved half-mask air-purifying respirator equipped with a HEPA filter with protection for organic vapors, acid gases, dusts, fumes, and mists, asbestos, and radionuclides. The protection for dusts, fumes, and mists shall be for a TWA less than 0.05 mg/m^3.

  Conventional eyeglass frames cannot be used with full-face mask respirators because of interference with the face seal. Special eyeglasses can be mounted inside the face mask; however, there is a delay to obtain prescription lenses.

The SSO shall specify which employees are required to wear the items listed above. The SSO shall instruct site personnel to don appropriate respiratory protection when air monitoring results show breathing zone concentrations of benzene greater than 1 ppm, or

when total hydrocarbon monitoring results for nonbenzene in the breathing zone are greater than 5 ppm. The SSO shall determine which level of personal protective items (gloves, goggles, etc.) is needed, based on professional judgment regarding site conditions and the likelihood of exposure. Respiratory protection should be used if personnel exposure above TLVs is probable, or if personnel desire protection for odor or nuisance mitigation.

Personnel who wear respirators will be trained in their proper usage, have a current medical examination, and have been fit tested within the past 12 months. Facial hair which interferes with the respirator seal must be removed prior to respirator usage (29 CFR 1910.134 and LLNL Respiratory Protection Program).

It should be recognized that the nature of the potential hazards is such that it is not possible to provide maximum protection for all suspected contaminants. If unanticipated conditions are encountered that require additional personnel protection, the SSO shall ensure that appropriate additional personal protective apparel and equipment are in use prior to continuing activities under those conditions.

8.2. Apparel Decontamination

The SSO may establish at least one safety apparel decontamination station at the work site in the contamination reduction zone. At a minimum, soap/detergent, rinse water, towels, wash pans, and brushes for scrubbing boots shall be available. Decontamination is defined as removing any potentially contaminated soil from boots by washing with soap and water or removing boot covers in the contamination reduction zone upon exiting the work zone. Wash water will be available in a basin suitable for standing in while washing boots. If there is reason to believe that this wash water requires containment and disposal, it will be contained, sampled, and properly disposed of based upon the analytical results.

The location of the decontamination process will be selected to minimize the exposure of uncontaminated employees and equipment to the contaminated employees and equipment. The SSO will monitor decontamination procedures to determine their effectiveness.

In the event that permeable clothing should become wetted with hazardous substances, the employee will immediately remove that clothing and proceed to shower.

When protective clothing or equipment is sent to commercial cleaning establishments for decontamination, those establishments will be informed of the potentially harmful effects of exposures to the hazardous substances present.

If additional PPE is used, such as Polytyvek suits and chemical-resistant gloves, remove them in the contamination reduction zone after leaving the work zone. If this equipment is used, it must be decontaminated or disposed of properly.

8.3. Equipment Decontamination

Soils remaining on tools, sampling equipment, or heavy equipment will be removed by steam cleaning. If there is reason to believe that the water used for this decontamination procedure requires containment and disposal, it will be contained and properly disposed of based upon analytical results.

8.4. Personnel Decontamination and Personal Hygiene

Personnel may be subject to skin or eye irritation from contaminants. Before eating, drinking, or smoking, site workers should thoroughly wash their hands and other exposed skin surfaces after leaving a contaminated area Workers should shower and change clothes at the end of the work shift to ensure that contaminants from the site are not transferred into personal vehicles or taken home on soiled clothing.

Where regular showers and change rooms are needed for decontamination outside of contaminated areas, they will meet the requirements of 29 CFR 1910.141, "SANITATION." Protective equipment and/or clothing will not be removed from change-rooms by unauthorized personnel.

8.5. Monitoring Equipment

The SSO shall ensure that all necessary monitoring equipment is available in sufficient quantities prior to work initiation. Other equipment deemed necessary by the SSO, based on the potential for contamination, shall be obtained at his direction prior to work initiation. The SSO shall also ensure that these instruments are used only by persons who have had prior experience with their care, calibration, and operation and who know their limitations. No work shall be done unless this instrumentation is available and in proper working order.

8.5.1. Monitoring Rationale

Monitoring shall be sufficient to determine:

- Airborne concentrations of hazardous chemical substances.
- Combustible gas and oxygen levels.
- Surface contamination of work areas.
- Contamination of personal protective apparel and equipment.
- Personnel contamination.
- Suitability of release of equipment and material to unrestricted areas.

8.5.2. Equipment

The SSO, or his designee, may use any or all of the following monitoring equipment to assist in evaluating potential hazards:

- Combustible gas/oxygen meter.
- Passive chemical dosimeters (i.e., 3M Organic Vapor Monitor, Draeger Direct-Reading Diffusion Tubes).
- Other real-time monitoring instruments (i.e., hydrogen sulfide, carbon monoxide, etc.).
- Photoionization detector (PID).
- Flame ionization dectector (FID).

- Hand pump (e.g., Draeger) with colorimetric detector tubes for specific compounds, particularly benzene.
- Constant flow personnel air sampling pumps, which can be calibrated to appropriate volumetric air flow rates to collect airborne samples consistent with NIOSH requirements. The other items required for air sampling include: tubing, filter cassette holders, charcoal tubes, filters, and calibration equipment.
- Radiation detection equipment/monitors.

8.5.3. Initial Monitoring

A preliminary survey of existing air quality is performed by a qualified person to determine the presence of any of the following conditions prior to commencement of operations:

- Immediately dangerous to life and health (IDLH).
- Potential exposure to hazardous substance in excess of PEL or other published exposure limit when applicable.
- Exposure to radioactive substances in excess of established dose limits.
- Exposure to other dangerous conditions (i.e., flammable atmospheres or oxygen deficiency).

The site is initially inspected for visual signs of dangerous conditions and surveyed with a OVM or OVA and a combustible gas/oxygen meter prior to initiation of any work activities to establish background levels for use in proper selection of engineering controls, safe work practices, and PPE. Where radiation is anticipated, the site is also surveyed with radiation detection equipment.

If the presence of other hazardous substances not detectable with the above equipment is anticipated (hydrogen sulfide, carbon monoxide, etc.), the appropriate monitoring equipment will be used to survey the site (i.e., Drager detector tubes, substance-specific monitors, etc.).

This survey will focus on the following areas:

- The contamination reduction zone downwind from drilling activities, excavation, and other work activities.
- Locations where workers may assemble or congregate.
- Confined spaces or areas where gases may be trapped.

8.5.4. Periodic Monitoring

When the potential for exposure is unknown, periodic monitoring of onsite ambient concentrations of VOCs in the immediate vicinity of work activities will be performed using a OVM or OVA. The SSO will compare monitoring results with OSHA standards and other exposure guidelines to ensure that proper protection is provided.

Where work activities may generate dust contaminated with beryllium or lead, it may be necessary to use a calibrated sampling pump to collect an airborne sample of particulate on a

filter. When this is done, samples should be analyzed by an American Industrial Hygiene Association (AIHA) accredited laboratory according to NIOSH procedures.

Caution is necessary during any fuel tank excavation and removal. OVM or OVA results are not compound specific; the instrument reading is for total organic vapors. When benzene is a potential exposure problem, a direct readout of benzene vapor concentrations should be obtained using an instrument similar to a Draeger pump with a colorimetric detector tube specific for benzene. Personnel protection, respirator selection, monitoring, and operational protocols and procedures must be developed for work atmospheres where benzene concentrations are greater than the PEL of 1 ppm.

Periodic monitoring shall be performed whenever there is a possibility that an IDLH condition or explosive atmosphere has developed or when an indication that exposure may be in excess of the PEL or other published exposure limits. When any of following situations exist, additional precautions shall be considered:

- Initiation of work in a different portion of the site.
- If new contaminants are known to be, or suspected of being present.
- When employees are handling leaking containers or working in areas with obvious contamination.
- Upon initiation of a different type of opeartion.

8.5.5. High Risk Employees

The employees who are most likely to be exposed to hazardous substances above the PEL or other applicable published exposure limits will be monitored first. If they are being exposed to levels above the PEL, then monitoring will be performed to establish which other employees, if any, may also be exposed above PEL.

8.5.6. Perimeter Monitoring

Under certain circumstances, it may be necessary to conduct perimeter monitoring to evaluate emissions resulting from work covered by this Plan. If such monitoring is conducted and results are higher than baseline levels of any contaminant, immediate steps will be taken to determine the cause, make changes to site operations, evacuate unprotected personnel and the public, if necessary, and notify agency contact personnel. Specific protocols to be implemented shall be determined by the SSO and the Project Leader for each incident.

8.6. First Aid and Safety Equipment

To provide first response assistance to field personnel in the event of an injury or illness, the SSO shall have the following items immediately available at the site investigation command post, or at work areas, as appropriate:

- First aid kit.
- First aid handbook.

- Portable emergency eyewash station or bottles.
- Supply of clean water.
- Hand soap, or waterless hand cleaner, and clean hand towels.
- Portable cooler with drinking water (or replenishment drink such as Gatorade) and ice.

9. Personnel Training

Individuals assigned to this project who may be exposed to physical and chemical hazards shall undergo training to:

- Ensure that the health and safety of LLNL employees, contractor employees, employees or representatives of other agencies, and the public is maintained.
- Safeguard the health and safety of all employees and the public by complying with all laws, rules, and regulations.
- Increase the ability of employees to react responsibly to emergencies and to handle emergency situations in a safe manner.
- Increase the ability of employees to complete their work in an efficient and timely manner.

9.1. Hazardous Waste Operations and General Safety Requirements

All personnel working on hazardous waste cleanup sites at LLNL who may be exposed to physical and chemical hazards shall attend 40 hours of health and safety training, 24 hours of on-the-job field training under supervision, or other combinations deemed equivalent by the SSO, as specified in OSHA 29 CFR 1910.120. Personnel will be trained prior their participation in field activities and written certificates are to be issued upon successful completion of that training. The Project Leader, SSO, and contractor supervisors are required to complete an additional 8 hours of "Hazardous Waste Management" training. All site personnel are required to complete 8 hours of "Refresher" training annually.

Instructors shall have completed a training program for the subjects that they are expected to teach or have academic credentials and instructional experience for teaching the subjects.

The above requirements address minimal training needs and additional training will be provided as deemed appropriate.

At a minimum, worker training should address the following topics:

- Names of personnel and alternates responsible for site health and safety.
- Onsite Medical Surveillance and Signs of Overexposure.
- Elements of the Site Safety Plan and any applicable OSP.
- Program Discussion/Regulatory Overview.
- Training Rationale.
- Chemical and Physical Hazards.
- Toxicology.
- Medical Surveillance Program.
- Environmental Planning

Hazards Analysis
Work Plan
Site Safety Plan.

- Characterization and Site Activities.
- Site Control.
- Personal Protective Equipment

  Clothing
  Respirators and Fit Testing.

- Air Monitoring.
- Decontamination.
- Emergencies.
- Site Operations.
- Hazardous Substance Identification.
- Hazard Communication Program.

9.2. Work Site Specific Topics

All site personnel (LLNL employees and contractors) shall attend a site-specific training session which addresses: nature and degree of exposure anticipated at the site; prohibited practices; emergency procedures; site-specific safety requirements; and general safety requirements.

9.2.1. Prohibited Practices

The following practices must be strictly observed at all times during the project work. The prohibitions shall remain in effect from the time of entry into the work site until after leaving that portion of the site. They include:

- Eating, chewing, drinking, or smoking items will not be allowed past the Contamination Control Line (i.e., "Hotline"). Avoid all hand-to-mouth contact when your clothing or body may be contaminated (i.e., be careful until *after* showering). Any open wounds must be covered with an air-tight bandage; ideally, someone with an open wound should not enter a work site. Persons with lesions or sores in the mouth, eyes, or nose shall not enter the work site.
- Never climb over or under any refuse or obstacles.
- Facial hair that may interfere with the satisfactory fit of respiratory protective equipment will not be allowed. Workers with beards will not be allowed to do work requiring respiratory protection.
- Personnel may not wear loose, ragged, or poorly fitted clothing, dangling jewelry, or rings when working around equipment or tools. Long hair must be restrained so that it does not get caught in moving parts. Any of these items can become snagged in moving equipment and result in serious injury.

- Alcohol and/or drugs are not permitted at the site. Any person reporting to work under the influence of alcohol and/or illegal drugs will be permanently prohibited from working at the site.

The following prohibitions and practices shall be in effect when deemed necessary by the SSO due to the existence of hazardous conditions at the work area:

- Do not wear contact lenses. Eye contamination while wearing contact lenses can result in serious injury to the eye before the lens can be removed and the eye properly washed.
- Practice contamination avoidance: never sit down or kneel, never place equipment on contaminated surfaces, avoid obvious sources of contamination such as puddles, avoid unnecessary contact with on-site objects.
- Do not start or maintain an open flame of any type unless authorized.
- No employee may enter a work site alone or work alone without prior approval. Special work tasks, such as water level measurements or water sampling, may require that an individual work alone. In such cases, procedures shall be developed delineating emergency response and communication activities and responsibilities.

In addition to the prohibitions and practices listed above, the SSO may impose any other prohibitions which he/she believes may be required for safe operations.

9.2.2. Emergency Procedures and Services

The training session should include:

- LLNL Emergency Response Dispatch (**911**).
- Signals, alarms, and hazard signs.
- Evacuation routes and procedures.
- Assembly points.
- Buddy system.
- Communications.
- Fire protection.
- Barricades and scaffolds.
- Emergency equipment.
- First aid and contaminated wounds.
- Spills.

Refer to page 1 of this document for emergency telephone numbers and Section 7 of this document for emergency procedures.

9.2.3. General Safety Requirements

All project work shall be performed in a manner consistent with providing a safe work environment. General safety guidelines are to:

- Wear appropriate protective clothing for the job, including, but not limited to, hard hat, work clothing, safety shoes, and eye protection.
- Decontaminate known sources of contamination (such as gloves and boots) at the appropriate location as specified by the SSO. Remove equipment only after decontamination or containerization onsite.
- Keep track of weather conditions and wind direction when working outside.
- Plan activities thoroughly ahead of time: enter work sites by a designated route only to get to a designated point for a specific purpose.
- Always use the buddy system: never enter or exit alone, and never work alone in an isolated area.
- Always maintain contact with the SSO and the Ground Water Project Trailer (T-4383), where site access and operations are controlled. Trailer 4383 should be continuously occupied while team members are onsite.
- Shower thoroughly as soon as possible after removing protective equipment.
- Wash hands thoroughly upon leaving any area of suspected contamination.
- All personal safety equipment is to be inspected prior to work site entrance. The condition of the equipment must be acceptable to the SSO.
- All personnel who will enter a work site should wear secure identification (e.g., badge with photo and name; name on clothing). A name on the hard hat is *not* secure identification. Identification must be visible even when all PPE or gear is worn.
- Never assume that a situation is as safe as it appears to be.
- Be alert to any unusual behavior on the part of other workers that might indicate distress, disorientation, or other ill effects. Be alert to any unusual changes in your own condition; never ignore warning signs or hesitate to report them at once. Inform each other of symptoms of nausea, dizziness, headache, or respiratory or eye irritation.
- Maintain a clean and organized work area.
- Delineate work zones with barricades and markers.
- Label raw materials, debris, scrap, waste, intermediates, and contaminated clothing with appropriate and understandable precautionary labels.
- Post warnings in areas with high noise levels and require PPE.
- Inspect fire extinguishers monthly for adequate pressure.
- Inspect emergency eyewash/showers daily for proper operation, before work begins.
- Only trained and experienced operators are to operate heavy equipment onsite.

9.3. Field Briefings

The SSO, or a designee, shall conduct daily health and safety field briefings that include

- Work activities that day.
- Health and safety requirements for that day.
- Work zones.
- Evacuation routes.
- Assembly point upwind of work area, in case of emergency or evacuation.
- Emergency signals.
- Location of first aid and emergency safety equipment.

9.4. First Aid

The SSO, or a designee, shall identify those individuals who have previously completed training programs in First Aid and CPR. These individuals should be appointed as alternates for the SSO if he/she is incapacitated or needs assistance. Specific responsibilities will be assigned to these individuals by the SSO, who will take into consideration their familiarity with the following topics:

- Principles of first aid.
- Restoration of breathing/CPR.
- Control of bleeding.
- Recognition and treatment of physical shock.
- Open and closed wounds and burns.
- Fractures and dislocations.

10. Operations

Operations shall be conducted in a safe manner consistent with the policies and procedures outlined in this Plan. The number of personnel shall be restricted to the minimum necessary to complete the required work as an administrative control to limit the exposure of personnel to chemical hazards onsite.

10.1. Work Site Practices

The prohibited practices and general safety requirements listed in Section 9 are applicable to this site work. In addition, no worker may engage in any activity for which the health and safety consequences of his/her actions are unclear (e.g., previously unplanned work) without the approval of the SSO. If such activities become necessary to complete any phase of the work, a project instruction or procedure shall be developed and followed.

Smoking will not be permitted in any restricted work location or other locations posted "No Smoking" by LLNL.

10.2. Work Zones

Site access shall be controlled to reduce the possibility of entry by unauthorized or unprotected individuals and prevent the transfer of contaminants by personnel or equipment from the site. Three zones, the exclusion zone, the contamination reduction zone, and the support zone, will be delineated by barricades and flagging as appropriate. Zones will be established by the SSO based on local conditions. In most situations, such as during drilling operations in small, individual areas, only a barrier delineating the exclusion zone and the support zone will be needed.

The SSO or designee will be alert to persons entering active zones and will prohibit unauthorized or unprotected persons from entering these zones. Zones may be modified or expanded by the SSO depending upon changing wind and site conditions.

10.2.1. Exclusion Zone

The exclusion zone shall include, at a minimum, the immediate vicinity of the work area (such as the drill rig and the boring location at the rear of the rig) plus an additional 15-foot corridor. Persons entering this zone are required to wear PPE as prescribed by the SSO for that particular zone.

10.2.2. Contamination Reduction Zone

The contamination reduction zone shall be located upwind of the exclusion zone. The purpose of this zone is to prevent the transfer of contaminants by personnel or equipment exiting the exclusion zone. All decontamination activities shall occur in this area.

In the case of drilling rig activities, a separate contamination reduction zone may not be necessary. It will usually suffice to establish a decontamination point at the entrance/exit to

the barricade around the drilling site. Personnel may discard any contaminated articles before stepping outside of the barrier into the support zone (the remainder of the site).

10.2.3. Support Zone

The support zone is the outermost zone and is considered a noncontaminated (or clean) area. Any supplies, equipment, or personnel required to support site activities should be kept in this zone. The support zone shall be upwind of the contamination reduction and exclusion zones.

10.3. Security Measures

All areas and containers where potentially contaminated soil or water are to be stored unattended and any excavations that are to be left open and unattended are to be surrounded by a barricade to prevent accidental access by unauthorized personnel. Potentially contaminated soil shall be properly packaged and labeled.

10.4. Hazard Control Measures

Specific considerations shall be given to the following topics to ensure that adequate hazard control measures are implemented for site operations:

- Minimization of dust generation (e.g., applying water when excavating or drilling).
- Prevention of surface contamination by subsurface material or vice versa.
- Decontamination of sampling equipment.
- Decontamination of excavation/construction/maintenance equipment.
- Decontamination and disposal of personnel protective apparel and equipment.
- Use of decontamination solutions–acids, alkalis, or solvents.
- Disposal of decontamination solutions and other materials used on equipment, surfaces, or systems.
- Disposal of drilling spoils and other wastes associated with environmental characterization.
- Disposal of contaminated materials by placing them in 55-gallon drums, which may be sealed, labeled, and disposed of as necessary.
- Monitoring for flammable/explosive vapors.
- Minimization of personnel exposures through appropriate use of administrative work practices consistent with ALARA.
- Handling and disposal of contaminated water, filtrates, etc.
- Use and operation of electrical equipment (see Appendix D).
- Use and maintenance of personnel protective apparel and equipment.
- Heavy equipment operations and safety protocols (see Appendix E).

- Personnel air monitoring protocols for evaluation of full-shift and short-term chemical exposures.
- Direct reading instrumentation protocols and techniques for estimating real-time chemical exposures onsite.
- Respiratory protection as per 29 CFR 1910.134 and ANSI Z88.2.

The Hazards Control Department, Safety Team Four, can be contacted for guidance and evaluation.

10.5. Fire Protection

To ensure that fire and explosion hazards are minimized, plans and procedures must be coordinated with the LLNL Fire Department (911). If suitable water supplies are unavailable or where water use may be inappropriate, 20- or 30-lb ABC fire extinguishers may be necessary for each drill rig or field crew. No smoking is allowed in the work area nor near any flammable materials. Any use of open flame requires prior authorization by the SSO.

Employees are informed of the fire hazards of the materials and processes to which they are exposed. Upon initial assignment, each employee will be trained in the portions of the fire prevention plan that will protect the employee in the event of an emergency.

The hazardous work sites at LLNL have the fire hazards typical of construction sites and chemical treatment facilities such as: combustible and flammable materials, potential for explosive atmospheres, occasional welding and open flames, oxidizers, and motor fuels.

The LLNL Fire Department and the SSO are responsible for the maintenance of any fire prevention and suppression systems or equipment used on the hazardous work sites.

The accumulation of flammable and combustible waste materials will be minimized as a means of fire prevention.

10.6. Communications

The SSO shall maintain contact with workers on a continuing basis. Individuals shall meet and register at the checkpoint established by the SSO prior to work site entry. Each worker shall ensure that he maintains contact with other workers or his "buddy." No individual may either enter or leave the work site alone. Exiting workers shall inform the SSO, or a designee, that they are departing.

10.7. Personnel Protection Plan

Environmental operations pose unusual health and safety problems. A very careful review of OSHA and EPA regulations, standards, and guidelines by the SSO is important. At a minimum, these requirements may include:

- Medical surveillance.
- Personnel exposure monitoring program.
- Respiratory protection.

- PPE and clothing.
- Prohibited activities.
- Compliance program.
- Hygiene facilities and practices.
- Employee information and training.
- Recordkeeping.

10.8. Safety

The industrial health and fire safety aspects of this program will focus on evaluation of hazards associated with:

- Transportation equipment.
- Material handling equipment.
- Machinery and parts.
- Hand tools and pressurized equipment.
- Hazardous supplies and materials.
- Fire protection.
- Electrical equipment (i.e., motors, relays, and starters).

Prior to the initiation of work and weekly thereafter, safety inspections will be conducted by the SSO or a designee. This inspection will include those activities necessary to ensure the safe operating condition of all equipment consistent with 29 CFR 1910 and 1926 and the LLNL Safety Manual. Additionally, it will be the responsibility of LLNL's subcontractors to provide a routine maintenance program for this equipment.

The areas accessible by employees will be provided with adequate illumination while work is in progress in accordance with Table H120.1.

Table H120.1. Minimum illumination intensities in foot-candles

Foot-candles	Area or operations
5	General site areas.
3	Excavation and waste areas, accessways, active storage areas, loading platforms, and field maintenance areas.
5	Indoors: warehouse, corridors, hallways, and exitways.
5	Tunnels, shafts, and general underground work areas. (Exception: minimum of 10 foot-candles is required at tunnel and shaft heading during drilling, mucking, and scaling. Mine Safety and Health Administration approved cap lights shall be acceptable for use in the tunnel heading.
10	General shops (e.g., mechanical and electrical equipment rooms, active storerooms, barracks or living quarters, locker or dressing rooms, dining areas, and indoor toilets and workrooms).

Although drums and containers of hazardous waste are not routinely handled during site operations, the provisions of Paragraph J, "Handling Drums and Containers," shall be implemented when appropriate.

10.9. Recordkeeping

Health and safety records shall be maintained in accordance with applicable regulatory requirements. Records are maintained for LLNL personnel at the LLNL Environmental Protection Department offices: these records document safety training, medical surveillance, respiratory protection training and testing, injuries, and illnesses. All subcontractors working on the project are required to maintain similar records at their respective offices.

11. Bibliography

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TLVs Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment and Biological Exposure Indices with Intended Changes for 1984-85, American Conference of Governmental Industrial Hygienists.

Appendix A
Site-Specific Operational Safety Procedures

Appendix A

Site-Specific Operational Safety Procedures

The Site-Specific Operational Safety Procedures (OSPs) supplements the LLNL General Site Safety Plan and provides detailed information for a specific operation not fully addressed in the Plan. A copy of the OSP shall be kept at the work site at all times. The OSPs typically includes the following items as applicable and any additional items deemed necessary:

A. Hazard Assessment For Each Task in Work Plan.

B. Personal Protective Equipment For Each Task.

C. Type and Frequency of Air Monitoring.

D. Site Control Measures.

E. Decontamination Procedures.

F. Spill Containment Program.

G. Employee Training Assignments.

H. Confined Space Entry Procedures.

I. Emergency Response Procedures.

J. Site Inspections.

K. Medical Surveillance.

L. Pre-Entry Briefing.

Appendix B
Acronyms

Appendix B

Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ALARA	As low as reasonably achievable
ALI	Allowable Limit on Intake (μCi). The ALI is the annual intake that would lead to an effective committed dose equivalent not exceeding 5 rem and an annual dose equivalent to any single organ or tissue not exceeding 50 rem
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CPR	Cardiopulmonary resuscitation
DAC	Derived Air Concentration ($\mu Ci/cm^3$). The DAC is the average atmospheric concentration that would lead to the ALI in a reference person exposed to the DAC for a 2,000-hour work year
DHS	Department of Health Services
DOE	Department of Energy
DTSC	California Department of Tox Substances Control
EPA	Environmental Protection Agency
ERD	Environmental Restoration Division
$f1$	Retention factor in organs of the body by specific radioactive isotopes
FID	Flame Ionization Detector
HEPA	High Efficiency Particulate Arrestor
HTO	Tritiated water
IDLH	Immediately Dangerous to Life or Health concentration that represents the maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any other irreversible health effects
LEL/UEL	Lower and Upper Explosive Limits; percent by volume of potentially explosive substance in air
LFL/UFL	Lower and Upper Flammable Limits; percent by volume of potentially flammable substance in air
LLNL	Lawrence Livermore National Laboratory
MSDS	Material Safety Data Sheets
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
OSPs	Operational Safety Procedures

PEL	Permissible Exposure Limit set by OSHA; values usually are expressed in ppm or mg/m^3. PELs are expressed as: • 8-hour TWA exposure limit. • Ceiling exposure limit (CEIL); at no time shall an employee's exposure exceed this limit. • Short-term exposure limit (STEL); the maximum exposure in any 15-minute period. • Maximum peak (PEAK); acceptable above the specified ceiling limit for the stated concentration and duration.
PID	Photoionization Detector
PPE	Personal Protective Equipment
SSO	Site Safety Officer
TLV	Threshold limit value as issued by ACGIH; values usually are expressed in ppm or mg/m^3. TLVs are expressed as: • TLV-TWA: the TWA concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. • TLV-STEL: the 15-min TWA to which a worker can be exposed for a period of up to 15 minutes continuously without suffering from irritation, chronic or irreversible tissue damage, or narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce worker efficiency, and provided that the daily TLV-TWA is not exceeded.
TWA	Time-weighted average; this is generally expressed as an 8-hour TWA
VOCs	Volatile organic compounds
XLM, XLO, and XLP	The m, o, and p isomers of xylene

Appendix C
Material Safety Data Sheets

Appendix C

Material Safety Data Sheets

Benzene MSDS #Genium/316

Carbon Tetrachloride ($CHCl_4$) MSDS #Genium/410

Chloroform MSDS #Genium/315

1,1-Dichloroethane (1,1-DCA)

1,2-Dichloroethane (1,2-DCA) MSDS #/359

1,1-Dichloroethylene (1,1-DCE)

1,2-Dichloroethylene (1,2-DCE)

Diesel

Gasoline, Automotive Lead Free MSDS #Genium/467

Perchloroethylene (PCE) MSDS #Genium/313

Trichloroethylene (TCE) MSDS #Genium/312

Toluene MSDS #Genium/317

Tritium

Xylene MSDS #Genium/318

Material Safety Data Sheet

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1145 Catalyn Street, Schenectady, NY 12303
(518) 377-8854
From Genium's collection, to be used as reference

Product: BENZENE

MSDS No: Genium / 316
Revision: D
Date: April, 1988

National Paint and Coatings Association Hazardous Material Identification System		
	HEALTH HAZARD	2 - Moderate
	FLAMMABILITY HAZARD	3 - Serious
	REACTIVITY HAZARD	0 - Minimal
	PERSONAL PROTECTION	SEE SECTION 8

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: BENZENE

Description: Used in the manufacture of medicinal chemicals, dyes, linoleum, airplane dopes, varnishes, and lacquers; and as a solvent for waxes, resins, and oils.

Other Designations: Benzol; Phene; Phenylhydride; C_6H_6; NIOSH RTECS No. CY1400000

CAS: 0071-43-2

R 1
I 4
S 2
K 4

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the Chemicalweek Buyers' Guide (Genium ref. 73) for a list of suppliers.

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	CAS Number:	Percent:	Exposure Limits:
Benzene	0071-43-2	Ca 100	OSHA PEL 8-Hr TWA: 1 ppm 15-Min Ceiling: 5 ppm Actin Level: 0.5 ppm ACGIH TLV, 1987-88 TLV-TWA: 10 ppm, 30 mg/m^3 Toxicity Data* Human, Inhalation, LC_{Lo}: 2000 ppm/5 Min Human, Oral, TD_{Lo}: 130 mg/kg Human, Inhalation, TC_{Lo}: 210 ppm

 INGREDIENTS AND HAZARDS continues on page 2

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INGREDIENTS AND HAZARDS continued from page 1

* See NIOSH, RTECS, for additional data with references to irritative, mutagenic, tumorigenic, and reproductive effects.

SECTION III. PHYSICAL DATA

Appearance & Odor: A colorless liquid; characteristic aromatic odor.

Boiling point: 176°F (80°C)
Vapor pressure: 75 Torrs at 68°F (20°C)
Water solubility (%): Slight
Vapor density (air=1): >1
Specific gravity (H_2O=1): 0.87865 at 68°F (20°C)
Melting point: 42°F (5.5°C)
% volatile by volume: 100
Molecular weight: 78 Grams/Mole

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point (method): 12°F (-11.1°C) (CC)Limits: LEL %: 1.3 UEL %: 7.1

NFPA Fire Hazard Symbol Codes: Flammability: 3 Health: 2 Reactivity: 0 Special:

Extinguishing Media: Use dry chemical, foam, or carbon dioxide to put out benzene fires. Water may be ineffective as an extinguishing agent because it can scatter and spread the fire. Use water to cool fire-exposed containers, flush spills away from exposures, disperse benzene vapor, and protect personnel attempting to stop an unignited benzene leak.

Autoignition Temp: 928°F (498°C)

Unusual fire or explosion hazards: Benzene vapor is heavier than air and can collect in low-lying areas such as sumps or wells. Eliminate all sources of ignition there to prevent a dangerous flashback to the original liquid benzene.

Danger: Explosive and flammable benzene vapor-air mixtures can easily form at room temperature; always use this material in a way that minimizes dispersion of its vapor into general work areas.

Special fire-fighting procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

MSDS 316 continues on page 3

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SECTION V. REACTIVITY DATA

Material is stable in closed containers during routine operations. Hazardous polymerization does not occur

Chemical incompatibilities: Hazardous chemical reactions involving benzene and the following materials are reported in Genium reference 84: bromine pentafluoride, chlorine, chlorine trifluoride, chromic anhydride, nitryl perchlorate, oxygen, ozone, perchlorates, perchloryl fluoride and aluminum chloride, permanganates and sulfuric acid, potassium peroxide, silver perchlorate, and sodium peroxide.

Conditions to avoid: Avoid all exposure to sources of ignition and to incompatible chemicals.

Hazardous decomposition Products: Toxic gases like carbon monoxide (CO) may be produced during benzene fires.

SECTION VI. HEALTH HAZARD INFORMATION

This product is considered a suspected human carcinogen by ACGIH.

Summary of risks: Prolonged skin contact with benzene or excessive inhalation of its vapor may cause headache, weakness, loss of appetite, and lassitude. Continued exposure can cause collapse, bronchitis, and pneumonia. The most important health hazards are cancer (leukemia), bone marrow effects, and injuries to the blood-forming tissue from chronic low-level exposure.

Medical conditions which may be aggravated by contact: Ailments of heart, lungs, liver, kidneys, blood, and central nervous system (CNS) may be worsened by exposure. Administer preplacement and periodic medical exams emphasizing these organs' functions and reassign workers who test positive.

Target organs: Blood, CNS, skin, bone marrow, eyes, and upper respiratory tract (URT).

Primary entry route(s): Skin contact, inhalation.

Acute effects: Dizziness, mental dullness, nausea, headache, fatigue, and giddiness.

Chronic effect(s): Possible cancer (leukemia).

First aid:

Eye contact: Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes.

Skin contact: Immediately wash the affected area with soap and water.

 HEALTH HAZARD INFORMATION continues on page 4

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HEALTH HAZARD INFORMATION continued from page 3

Inhalation: Remove the exposed person to fresh air; restore and/or support his or her breathing as needed.

Ingestion: Never give anything by mouth to someone who is unconscious or convulsing. Do not induce vomiting because of the possibility of aspiration.

GET MEDICAL HELP (IN PLANT, PARAMEDIC, COMMUNITY) FOR ALL EXPOSURES. Seek prompt medical assistance for further treatment, observation, and support after first aid.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Notify safety personnel, provide ventilation, and eliminate all sources of ignition immediately. Cleanup personnel need protection against contact with and inhalation of vapor (see sect. 8). Contain large spills and collect waste or absorb it with an inert material such as sand, earth, or vermiculite. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of sewers, watersheds, and waterways.

Waste management / Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Air Contaminant (29 CFR 1910.1000 Subpart Z)

EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste, No. U019
CERCLA Hazardous Substance, Reportable Quantity: 1000 lbs (454 kg)

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, wear a full face shield. Follow the eye- and face-protection guidelines in 29 CFR 1910.133.

Respirator: Wear a NIOSH-approved respirator per the NIOSH Pocket Guide to Chemical Hazards for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow the respirator guidelines in 29 CFR 1910.134. For emergency or nonroutine use (e.g., cleaning reactor vessels or storage tanks), wear an SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode.

Warning: Air-purifying respirators will not protect workers in oxygen-deficient atmospheres.

 SPECIAL PROTECTION INFORMATION continues on page 5

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Date: April, 1988

SPECIAL PROTECTION INFORMATION continued from page 4

Other: Wear impervious gloves, boots, aprons, gauntlets, etc., to prevent any possibility of skin contact with this suspected human carcinogen.

Workplace considerations:

Ventilation: Install and operate general and local ventilation systems powerful enough to maintain airborne levels of benzene below the OSHA PEL standard cited in section 2.

Safety stations:
Make eyewash stations, washing facilities, and safety showers available in use and handling areas.

Contaminated equipment:
Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do not wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from shoes and equipment.

Practice good personal hygiene; always wash thoroughly after using this material. Keep it off of your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do not eat, drink, or smoke in any work area. Do not inhale benzene vapor!

SECTION IX. SPECIAL PRECAUTIONS

Storage segregation: Store benzene in a cool, dry, well-ventilated area away from sources of ignition and incompatible chemicals.

Special handling / storage: Protect containers from physical damage. Electrically ground and bond all metal containers used in shipping or transferring operations. Follow all parts of 29 CFR 1910.1028.

Engineering controls: All engineering systems (production, transportation, etc.) must be of maximum explosion-proof design (nonsparking, electrically grounded and bonded, etc.).

If possible, substitute less toxic solvents for benzene; use this material with extreme caution and only if it is absolutely essential.

Transportation Data (49 CFR 172.101-2)
DOT Shipping Name: Benzene
DOT Label: Flammable Liquid
IMO Label: Flammable Liquid
IMO Class: 3.2

DOT Class: Flammable Liquid UN Register: UN1114
Data source code(s): 1, 2, 12, 73, 84-94, 100, 103.

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SPECIAL PRECAUTIONS continued from page 5

Prepared/revised by: Genium Publishing Corporation
April, 1988

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Material Safety Data Sheet

Genium Publishing Corporation
1145 Catalyn Street, Schenectady, NY 12303
(518) 377-8854
From Genium's collection, to be used as reference

Product: CARBON TETRACHLORIDE

MSDS No: Genium / 410
Revision: A
Date: December, 1980

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: CARBON TETRACHLORIDE

Other Designations: Tetrachlormethane, Perchlormethane, Methane Tetrachloride, DE350

CAS: 000 [illegible]

Available from several suppliers, including:

Manufacturer: Linden Chemicals & Plastics
PO Drawer J
Moundsville, WV 26041

Phone: (314) 843-1310

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	Percent:	Exposure Limits:
Carbon Tetrachloride	ca 100	8-hr TWA 5 ppm [illegible] or 30 mg/m³*
		Human, oral Ldlo 43 mg/kg Human, inhalation LCLo 1000 ppm TCLo 20 ppm (CNS) Hamsters and mice have developed cancer on long term feeding.

*ACGIH (1980 Intended Changes List). OSHA 8-hr TWA is 10 ppm. NIOSH has proposed a 10-hr TWA of 2 ppm. ACGIH and NIOSH recommend labeling as a suspected human carcinogen. (skin) notation indicates absorption through the skin can contribute significantly to overall exposure.

SECTION III. PHYSICAL DATA

Appearance & Odor: A clear, colorless liquid with a characteristic sweetish odor. Odor recognition threshold (100% of test panel): 21.4 ppm in air when prepared from CO_2; 100 ppm in air when prepared from CH_4. Odor may not be objectionable at acutely toxic levels.

PHYSICAL DATA continues on page 2

Material Safety Data Sheet

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Product: CARBON TETRACHLORIDE

MSDS No: Genium / 410
Revision: A
Date: December, 1983

PHYSICAL DATA continued from page 1

Boiling point: 1 atm: 76.7°C
Vapor pressure: ca 91 @ 20°C, mm Hg
Water solubility (%): 0.08 @ 20°C, wt %
Vapor density (air=1): 5.3

Specific gravity (H_2O=1): 1.594, 20/4
Melting point: -23°C
% volatile by volume: ca 100
Molecular weight: 153.82

SECTION IV. FIRE AND EXPLOSION DATA

Extinguishing Media: It is nonflammable. Use that which is appropriate for the surrounding fire. Use water spray to cool fire-exposed containers.

Special fire-fighting procedures: Firefighters must wear self-contained breathing apparatus and full protective gear to fight fires involving this material.

When involved in a fire situation, this material will emit highly toxic and irritating fumes and gases. Metals, such as aluminum and magnesium, can react violently with carbon tetrachloride when hot or burning.

SECTION V. REACTIVITY DATA

Material is stable under normal conditions of handling and use. Hazardous polymerization cannot occur

Chemical incompatibilities: Violent reactions or explosions can occur with incompatible materials, such as barium, lithium, sodium, and potassium metal, powdered aluminum, magnesium, dimethylformamide (above 65°C), fluorine, etc. (See NFPA, "Manual of Hazardous Chemical Reactions".)

Hazardous decomposition Products: Thermal-oxidative decomposition will produce toxic, corrosive fumes, including phosgene and hydrogen chloride.

SECTION VI. HEALTH HAZARD INFORMATION

Summary of risks: Carbon tetrachloride is highly toxic and irritating by inhalation and ingestion (mean lethal dose is 5-10 ml). It is toxic by skin absorption. Excessive exposure may result in CNS depression and/or gastrointestinal symptoms.* It is irritating to skin and eyes. Eye contact or systemic effects can produce visual disturbances (haze, blind spots, narrowing of visual field, etc.). Skin contact can cause defatting and dermatitis.

Acute effects: Kidney and liver damage can occur from severe acute or chronic exposure. It is a suspected carcinogen in humans.

 HEALTH HAZARD INFORMATION continues on page 3

Material Safety Data Sheet

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Product: CARBON TETRACHLORIDE

MSDS No: Genium / 410
Revision: A
Date: December, 1980

HEALTH HAZARD INFORMATION continued from page 2

First aid:

Eye contact: Flush eyes with running water for 15 minutes, including under the eyelids. Get medical help if irritation persists or when visual disturbances occur.

Skin contact: Remove contaminated clothing promptly. Wash exposed skin with soap and water. Get medical help for repeated or gross exposures.

Inhalation: Remove to fresh air. Restore and/or support breathing; have qualified person administer oxygen if needed. Get medical help.

Ingestion: Contact physician for gastric lavage. (If medical help and advice is not readily available, give water to drink and induce vomiting.)

*Also cardiac arrhythmias.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Notify safety personnel when large spills occur. Evacuate area. Provided maximum exhaust ventilation. Clean-up personnel must use protection against contact and inhalation (see Sect. VIII). Contain spill; pick up liquid for disposal. Small spills and residues can be absorbed on paper, vermiculite, etc. and allowed to evaporate in a hood. Prevent release of CCl_4 to surface water or sewers. Spills or discharges in 24 hours of 5000 lb or more (proposed RQ* is 1000 lb) must be reported to U.S. Government.

Waste management / Disposal: Consider recovery and reuse, if feasible. Scrap may be burned in approved, high temperature incinerator with scrubber or it may be disposed of as hazardous waste (EPA number U211 or F001 as a spent degreasing solvent under RCRA). Follow Federal, State and Local regulations.

*Reportable Quantity.

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:

Goggles: Wear safety goggles and/or face shield for eye protection.

Gloves: PVA or neoprene gloves needed to prevent skin contact.

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Product: CARBON TETRACHLORIDE

MSDS No: Genium 410
Revision: A
Date: December, 1989

SECTION VI. VENTILATION INFORMATION

Respirator: Use a [illegible] or pollution [illegible] ventilation above TLV, [illegible] factors above 10X ppm.

Other: Provide [illegible] and [illegible] medical exams. Workers with obesity, [illegible], alcoholism or liver problems should have a physical [illegible] before [illegible]. Retain medical records for 30 years after termination of employment. Provide training [illegible] to employees [illegible] the workplace. Monitor [illegible] levels in the workplace. See [illegible]

Workplace considerations:

Ventilation: Provide [illegible] and local exhaust ventilation to meet TLV. Exhaust hoods need 100 [illegible] face velocity. Ventilate sumps and low lying areas.

Safety stations:
An eyewash station and chemical safety shower should be readily accessible.

/Protective clothing needed to prevent skin contact.

SECTION IV. SPECIAL PRECAUTIONS

Storage segregation: Store in closed containers in a cool, dry, well-ventilated, low fire-risk area. Protect containers against physical damage. Keep away from sources of heat, direct sunlight, and incompatible materials (see Sect. V). Prevent exposure of vapors to high temperature to prevent decomposition to toxic and corrosive gases and vapors. No smoking in areas where vapors may be present.

Other precautions: Prevent contact with the skin or eyes. Avoid exposure to vapors. Use good personal hygiene. CCl_4 toxicity is markedly increased by the synergistic effects of alcohol. When possible, substitute a less hazardous solvent for CCl_4.

DOT Classification - ORM-A

Data source code(s): [illegible], 17, [illegible], 37, 38, 47, N

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Material Safety Data Sheet

Genium Publishing Corporation
1145 Catalyn Street, Schenectady, NY 12303
(518) 377-8854
From Genium's collection, to be used as reference

Product: CHLOROFORM

MSDS No: Genium / 315
Revision: 0
Date: April, 1988

National Fire Protection Association Hazard Identification System	HEALTH HAZARD	2 - Moderate
	FLAMMABILITY HAZARD	0 - Minimal
	REACTIVITY HAZARD	0 - Minimal
	PERSONAL PROTECTION	SEE SECTION 8

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: CHLOROFORM

Description: Used as a solvent for fats, oils, rubber, alkaloids, waxes, and resins; as a cleansing agent.

Other Designations: Trichloromethane; $CHCl_3$; NIOSH RTECS No. FS9100000

CAS: 0067-66-3

R 1
I 3
S 2
Y 0

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the Chemicalweek Buyer's Guide (Genium ref. 73) for a list of suppliers.

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	CAS Number:	Percent:	Exposure Limits:
Chloroform	0067-66-3	Ca 100	OSHA PEL Ceiling: 50 ppm, 240 mg/m³ ACGIH TLV, 1987-88 TLV-TWA: 10 ppm, 50 mg/m³ NIOSH REL Ceiling: 2 ppm, 9.78 mg/m³ Toxicity Data* Human, Oral, LD_{Lo}: 140 mg/kg Rat, Oral, LD_{50}: 908 mg/kg

* See NIOSH, RTECS, for additional toxicity data with references to mutagenic, reproductive, and irritative effects.

MSDS 315 continues on page 2

Material Safety Data Sheet

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(518) 377-8854
From Genium's collection, to be used as reference

Product: CHLOROFORM

MSDS No: Genium / 315
Revision: D
Date: April, 1988

SECTION III. PHYSICAL DATA

Appearance & Odor: A heavy, colorless, clear, volatile liquid; characteristic, pleasant, ethereal, sweet odor (recognition threshold: 0.3 mg/m³); sweet taste.

Boiling point: [illegible]
Vapor pressure: [illegible] Torr at [illegible]
Water solubility (%): 0.802 ml of $CHCl_3$ per 100 ml of [illegible] at [illegible]
Vapor density (air=1): 4.1

Specific gravity (H_2O=1): 1.484 at [illegible]
Melting point: -82.3°F (-63.5°C)
% volatile by volume: 100%
Molecular weight: 119 [illegible]

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point (method): *
Limits: LEL %: * **UEL %:** *

NFPA Fire Hazard Symbol Codes: Flammability: 0 **Health:** 2 **Reactivity:** 0 **Special:**

Extinguishing Media: * Chloroform does not burn. Use an agent that will put out the surrounding fire.

Autoignition Temp: *

Unusual fire or explosion hazards: None reported.

Special fire-fighting procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

SECTION V. REACTIVITY DATA

Material is stable if kept in closed containers and protected from air and sunlight. Hazardous polymerization does not occur. However, even when stabilized with ethanol, this material develops acidity from prolonged exposure to air and light.

Chemical incompatibilities: This material is incompatible with strong alkalies.

Conditions to avoid: Avoid prolonged exposure to air and light and to strong alkalies.

Hazardous decomposition Products: Toxic and corrosive gases like hydrochloric acid (HCl), chlorine (Cl_2), carbon monoxide (CO), and oxides of chlorine (ClO_x) can be produced during fires.

MSDS 315 continues on page 3

Material Safety Data Sheet

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Product: CHLOROFORM

MSDS No: Genium / 315
Revision: D
Date: April, 1988

SECTION VI. HEALTH HAZARD INFORMATION

This product is considered a suspected human carcinogen by ACGIH.

Summary of risks: Exposure to this material affects the central nervous system (anesthesia); heart (arrhythmia, ventricular tachycardia, bradycardia); liver (necrosis, hepatoma); kidney (necrosis); and it is an embryonic toxin. Fatalities are associated with cardiovascular depression and ventricular fibrillation.

Medical conditions which may be aggravated by contact: Ailments of the heart, liver, and kidneys may be worsened by exposure to chloroform.

Target organs: Liver, kidneys, heart, skin, eyes.

Primary entry route(s): Skin contact, inhalation.

Acute effects: Dizziness, mental dullness, nausea, headache, fatigue, and anesthesia.

Chronic effect(s): Possible cancer.

First aid:

Eye contact: Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes.

Skin contact: Immediately wash the affected area with soap and water.

Inhalation: Remove the exposed person to fresh air; restore and/or support his or her breathing as needed.

Ingestion: Never give anything by mouth to someone who is unconscious or convulsing. If the exposed person is responsive, give him or her several glasses of milk or water to drink and induce vomiting. Repeat if large quantities were ingested.

GET MEDICAL HELP (IN PLANT, PARAMEDIC, COMMUNITY) FOR ALL EXPOSURES. Seek prompt medical assistance for further treatment, observation, and support after first aid.

Comments: workers who are regularly exposed to chloroform require preplacement and periodic medical exams emphasizing kidney, liver, skin, and central nervous system functions. Carefully evaluate each exposure that produces a noticeable effect to determine the extent to which factors like alcohol or drugs have affected it.

MSDS 315 continues on page 4

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Product: CHLOROFORM

MSDS No: Genium / 315
Revision: D
Date: April, 1988

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Notify safety personnel of a chloroform spill or leak. Provide ventilation. Cleanup personnel need protection against contact with and inhalation of vapors (see sect. 8). Chloroform vapor is heavier than air and will collect in low-lying areas. Contain large spills and collect waste or absorb it with an inert material such as sand, earth, or vermiculite. Place waste liquid or absorbent into closable containers for disposal. Keep waste out of sewers, waterways and waterways.

Waste management / Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Air Contaminant (29 CFR 1910.1000 Subpart Z)

EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste, No. U044
CERCLA Hazardous Substance, Reportable Quantity: 5000 lbs (2270 kg)

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, wear a full face shield as a supplementary protective measure. Follow the eye- and face-protection guidelines in 29 CFR 1910.133.

Respirator: Wear a NIOSH-approved respirator per the NIOSH Pocket Guide to Chemical Hazards for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow the respirator guidelines in 29 CFR 1910.134. For emergency or nonroutine use (e.g., cleaning reactor vessels or storage tanks), wear an SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode.

Warning: Air-purifying respirators will not protect workers in oxygen-deficient atmospheres.

Other: To prevent contact with skin, wear impervious gloves, boots, aprons, gauntlets, etc., as required by the specific work environment.

Workplace considerations:

Ventilation: Install and operate general and local ventilation systems that are powerful enough to maintain airborne levels of chloroform below the OSHA PEL standard cited in section 2.

SPECIAL PROTECTION INFORMATION continues on page 5

Material Safety Data Sheet

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Product: CHLOROFORM

MSDS No: Genium / 315
Revision: D
Date: April, 1988

SPECIAL PROTECTION INFORMATION continued from page 4

Safety stations:
Make eyewash stations, washing facilities, and safety showers available in use and handling areas.

Contaminated equipment:
Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them. Do not wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from shoes and equipment.

Practice good personal hygiene; always wash thoroughly after using this material. Keep it off of your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do not eat, drink, or smoke in any work area. Avoid inhalation of vapor!

SECTION IX. SPECIAL PRECAUTIONS

Storage segregation: Store chloroform in closed containers away from light and alkalies.

Special handling / storage: Protect containers from physical damage. Do not transfer chloroform through plastic or rubber hoses or pipes.

Transportation Data (49 CFR 172.101-2)
DOT Shipping Name: Chloroform
DOT Label: None
IMO Label: Poison
IMO Class: 6.1

DOT Class: ORM-A **UN Register:** UN1888
Data source code(s): 1, 2, 12, 73, 84-94, 100, 103.

Prepared/revised by: Genium Publishing Corporation

April, 1988

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1,1-DICHLOROETHANE

DCH

Common Synonyms			
Ethylidene chloride Ethylidene dichloride Chlorinated hydrochloric ether	Oily liquid Sinks and mixes with water.	Colorless	Chloroform like ethereal

Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves)
Stop discharge if possible. Keep people away
Shut off ignition sources and call fire department.
Avoid contact with liquid
Isolate and remove discharged material
Notify local health and pollution control agencies.

Fire

Flammable.
POISONOUS GAS MAY BE PRODUCED IN FIRE OR WHEN HEATED.
Containers may explode in fire.
Wear goggles and self-contained breathing apparatus.
Extinguish with alcohol foam, carbon dioxide, or dry chemical
Water may be ineffective on fire.

Exposure

CALL FOR MEDICAL AID

LIQUID
If swallowed may cause nausea, vomiting and faintness.
Irritating to skin and eyes.
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 and induce vomiting.

Water Pollution

Dangerous to aquatic life in high 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-high flammability.
Restrict access.
Chemical and physical treatment.

2. LABEL

2.1 Category: None
2.2 Class: Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Halogenated hydrocarbon
3.2 Formula: $C_2H_4Cl_2$
3.3 IMO/UN Designation: Not listed
3.4 DOT ID No.: 2362
3.5 CAS Registry No.: 75-34-3

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Oily liquid
4.2 Color: Colorless
4.3 Odor: Chloroform

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: In areas of poor ventilation or high concentration, a self-contained breathing apparatus with full face mask should be worn. Chemical workers goggles, rubber gloves, and protective clothing should be worn.
5.2 Symptoms Following Exposure: INHALATION: Irritation of respiratory tract. Salivation, sneezing, coughing, dizziness, nausea, and vomiting. EYES: Irritation, lacrimation, and reddening of conjunctiva. SKIN: Irritation. Prolonged or repeated skin contact can produce a slight burn. INGESTION: Ingestion incidental to industrial handling is not considered to be a problem. Swallowing of substantial amounts could cause nausea, vomiting, faintness, drowsiness, cyanosis, and circulatory failure.
5.3 Treatment of Exposure: Call a doctor. INHALATION: Remove from contaminated area; keep warm and quiet. If breathing has stopped, give artificial respiration. Administer oxygen. EYES: Flush with large amounts of water or weak bicarbonate of soda solution. SKIN: Dilute with large amounts of water. Remove contaminated clothing. INGESTION: Attempt to empty stomach; dilute by administering fluids (tap water, soapy water, salt water, or milk).
5.4 Threshold Limit Value: 200 ppm.
5.5 Short Term Inhalation Limits: 250 ppm.
5.6 Toxicity by Ingestion: Grade 2; LD_{50} = 0.5 to 5 g/kg (rat).
5.7 Late Toxicity: Chronic exposure may cause liver damage and dermatitis. Animal experimentation has shown this compound to be slightly embryo-toxic and to retard fetal development.
5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.
5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin.
5.10 Odor Threshold: Data not available
5.11 IDLH Value: 4,000 ppm

6. FIRE HAZARDS

6.1 Flash Point: 57°F O.C. = 22°F C.C.
6.2 Flammable Limits in Air: 5.6% to 11.4%
6.3 Fire Extinguishing Agents: Alcohol foam, water, foam, CO_2, dry chemical, carbon tetrachloride
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective
6.5 Special Hazards of Combustion Products: When heated to decomposition emits highly toxic fumes to phosgene.
6.6 Behavior in Fire: Explosion hazard
6.7 Ignition Temperature: 856°F
6.8 Electrical Hazard: Data not available
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: 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: Table Data not available
7.7 Water Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: 36

8. WATER POLLUTION

8.1 Aquatic Toxicity:
TL_m (Marine pinperch) 250 to 275 mg/l
24-hour TL_m Brine shrimp: 320 mg/l
24-hour TL_m Pinperch: 160 mg/l
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): Percent, 0.05 g/g for 10 days Percent, 0.002 g/g for 5 days
8.4 Food Chain Concentration Potential: Data not available.

9. SHIPPING INFORMATION

9.1 Grades of Purity: Data not available
9.2 Storage Temperature: Cool
9.3 Inert Atmosphere: Data not available
9.4 Venting: Data not available

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-P-Q-R-S

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Not listed
11.2 NAS Hazard Rating for Bulk Water Transportation: Not listed
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: 98.97
12.3 Boiling Point at 1 atm: 135.14°F = 57.3°C = 330.5°K
12.4 Freezing Point: −143.32°F = −97.4°C = 175.75°K
12.5 Critical Temperature: 502.7°F = 261.5°C = 534.65°K
12.6 Critical Pressure: 734.8 psia = 50 atm = 5.065 MN/m²
12.7 Specific Gravity: 1.174 at 20°C
12.8 Liquid Surface Tension: 24.75 dynes/cm = 0.02475 N/m at 20°C
12.9 Liquid Water Interfacial Tension: Data not available
12.10 Vapor (Gas) Specific Gravity: 3.42
12.11 Ratio of Specific Heats of Vapor (Gas): 1.136 at 20°C (68°F)
12.12 Latent Heat of Vaporization: 131.6 Btu/lb = 73.1 cal/g = 3.06 X 10⁵ J/kg
12.13 Heat of Combustion: −4,774 Btu/lb = −2,652 cal/g = −111 X 10⁵ J/kg
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: Data not available
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: 7.35 psia

NOTES

Material Safety Data Sheet

From Genium's Reference Collection
Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8855

GENIUM PUBLISHING CORP.

No. 359
ETHYLENE DICHLORIDE
(Formerly 1,2-Dichloroethane)
(Revision C)
Issued: November 1978
Revised: August 1987

SECTION 1. MATERIAL IDENTIFICATION

CHEMICAL NAME: ETHYLENE DICHLORIDE (Changed to reflect common industrial practice)
DESCRIPTION (Origin/Uses): Made from acetylene and HCl. Used as a degreaser, a scavenger in leaded gasoline, as an intermediate in the manufacture of vinyl chloride, in paint removers, in wetting and penetration agents, in ore flotation processes, as a fumigant, and as a solvent for fats, oils, waxes, and gums.
OTHER DESIGNATIONS: 1,2-Dichloroethane; *sym*-Dichloroethane; Dutch Liquid; Dutch Oil; EDC; Ethane Dichloride; Ethylene Chloride; 1,2-Ethylene Dichloride; Glycol Dichloride; $C_2H_4Cl_2$; NIOSH *RTECS* KI0525000; CAS #0107-06-2
MANUFACTURERS/SUPPLIERS: Available from several suppliers, including: Dow Chemical USA, 2020 Dow Center, Midland, MI 48640; Telephone: (517) 636-1000

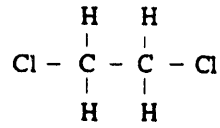
COMMENTS: Ethylene dichloride is a flammable, toxic liquid.

HMIS			
H	1	R	1
F	3	I	4
R	0	S	2
PPE*		K	4

* See Sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

Ingredients	%	HAZARD DATA
Ethylene Dichloride, CAS #0107-06-2; NIOSH *RTECS* #KI0525000	100	ACGIH Values 1987-88 TLV-TWA: 10 ppm, 40 mg/m^3 OSHA PEL* 1986-87 8-Hr TWA: 50 ppm; Ceiling: 100 ppm (15 Min.) NIOSH REL 1986-87 10-Hr TWA: 1 ppm Ceiling: 2 ppm (15 Min.) Toxicity Data Man, Inhalation, TC_{Lo}: 4000 ppm/1 Hr Human, Oral, TD_{Lo}: 428 mg/kg Man, Oral, TD_{Lo}: 892 mg/kg Man, Oral, LD_{Lo}: 714 mg/kg Rat, Oral, LD_{50}: 670 mg/kg



*The maximum allowable peak concentration (above the ceiling level value) of ethylene dichloride is 200 ppm for 5 minutes in any 3-hour period.
COMMENTS: Additional data concerning toxic doses and tumorigenic, reproductive, and mutagenic effects is listed (with references) in the NIOSH *RTECS* 1983-84 supplement, pages 865-66.

SECTION 3. PHYSICAL DATA

Boiling Point ... 182.3°F (83.5°C)
Vapor Pressure ... 87 Torr at 77°F (25°C)
Water Solubility ... Soluble in about 120 Parts Water
Vapor Density (Air = 1) ... 3.4
Evaporation Rate (n-BuAc = 1) ... Not Listed
Specific Gravity ... 1.2569 at 69°F (20°C)
Freezing Point ... -31.9°F (-35.5°C)
Molecular Weight ... 98.96 Grams/Mole

Appearance and odor: Colorless, clear liquid. Sweet, chloroformlike odor is typical of chlorinated hydrocarbons. The recognition threshold (100% of test panel) for ethylene dichloride is 40 ppm. Odor detection probably indicates an excessive exposure to vapor. High volatility and flammability, coupled with its toxicity and carcinogenic potential, make this material a major health hazard.
COMMENTS: Ethylene dichloride is miscible with alcohol, chloroform, and ether.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
See Below	775°F (413°C)	% by Volume	6.2	15.9

EXTINGUISHING MEDIA: Use chemical, carbon dioxide, alcohol foam, water spray/fog, or dry sand to fight fires involving ethylene dichloride. Direct water sprays may be ineffective extinguishing agents, but they may be successfully used to cool fire-exposed containers. Use a smothering effect to extinguish fires involving this material. UNUSUAL FIRE/EXPLOSION HAZARDS: Ethylene dichloride is a dangerous fire and explosion hazard when exposed to sources of ignition such as heat, open flames, sparks, etc. Its vapors are heavier than air and can flow along surfaces to distant, low-lying sources of ignition and flash back. If it is safe to do so, remove this material from the fire area. Ethylene dichloride burns with a smoky flame.
SPECIAL FIRE-FIGHTING PROCEDURES: Wear a self-contained breathing apparatus with a full facepiece operated in a pressure-demand or another positive-pressure mode.
COMMENTS: Flash Point and Method: 56°F (13°C) CC; 65°F (18°C) OC.
OSHA Flammability Class (29 CFR 1910.106): IB. DOT Flammability Class (49 CFR 173.115): Flammable Liquid

SECTION 5. REACTIVITY DATA

Ethylene dichloride is stable. Hazardous polymerization cannot occur.

CHEMICAL INCOMPATIBILITIES include strong oxidizing agents. Explosions have occurred with mixtures of this material and liquid ammonia or dimethylaminopropylamine. Finely divided aluminum or magnesium metal may be hazardous in contact with ethylene dichloride.
CONDITIONS TO AVOID: Eliminate sources of ignition such as excessive heat, open flames, or electrical sparks, particularly in low-lying areas, because the explosive, heavier-than-air vapors will concentrate there.
PRODUCTS OF HAZARDOUS DECOMPOSITION can include vinyl chloride, chloride fumes, and phosgene. Phosgene is an extremely poisonous gas. Products of thermal-oxidative degradation (i.e., fire conditions) must be treated with appropriate caution.

SECTION 6. HEALTH HAZARD INFORMATION

Ethylene dichloride is listed as an anticipated human carcinogen by the NTP and as a probable human carcinogen (Group 2B), by the IARC. It was found to be an animal-positive carcinogen by the IARC. NCI reported positive results (mouse, rat) from its carcinogenesis bioassay. SUMMARY OF RISKS: Ethylene dichloride is considered to be one of the more toxic of the common chlorinated hydrocarbons. Deaths from accidental ingestion of this material have been reported. Inhalation of vapors reportedly caused three fatalities. Excessive inhalation of ethylene dichloride vapors can cause respiratory irritation, intoxication, narcotic and anesthetic effects, vomiting, dizziness, depression, and diarrhea. The hepatoxic (injurious to liver) effects of this material are significant. The systemic effects from overexposure can appear in the liver, kidneys, digestive tract, blood, lungs, adrenal glands, and the central nervous system. Tests on animals have revealed reproductive failure and fetal resorption. There may be increased risk to nursing infants of exposed mothers. TARGET ORGANS: Central nervous system, eyes, kidneys, liver, heart, adrenal glands, and skin. PRIMARY ENTRY: Inhalation, absorption through skin, oral, or eye contact. ACUTE EFFECTS: Skin contact causes irritation, defatting, and, if repeated or prolonged, burning. Eye contact causes irritation and serious injury (clouding of the cornea) if it is not removed promptly. CHRONIC EFFECTS: Injuries to the liver (hepatoxicity) and kidneys, weight loss, low blood pressure, jaundice, oliguria (reduced excretion of urine), or anemia. MEDICAL CONDITIONS AGGRAVATED BY LONG-TERM EXPOSURE: Persons taking anticoagulants could experience an increase in tendency to bleed. Persons taking insulin face an increased risk of lowered blood sugar. FIRST AID: Be prepared to restrain a hyperactive victim. EYE CONTACT: Flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. Get medical help.* SKIN CONTACT: Immediately flush the affected area with water. Wash thoroughly with soap and water. Remove and launder contaminated clothing before wearing it again; clean material from shoes and equipment. Get medical help.* INHALATION: Remove victim to fresh air; restore and/or support his breathing as needed. Get medical help.* INGESTION: Never give anything by mouth to someone who is unconscious or convulsing. Rinse victim's mouth with water. Oxygen and artificial respiration may be needed. Get medical help.* * GET MEDICAL ASSISTANCE = IN PLANT, PARAMEDIC, COMMUNITY. Get prompt medical assistance for further treatment, observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK: Before using ethylene dichloride, it is essential that proper emergency procedures be established and made known to all personnel involved in handling it. Notify safety personnel of ethylene dichloride spills or leaks and implement containment procedures. Remove and eliminate all possible sources of ignition such as heat, sparks, and open flames from the area. Cleanup personnel should use protection against inhalation of vapors and contact with liquid. Contain spills by using an absorbent material such as dry sand or vermiculite. Use nonsparking tools to mix waste material thoroughly with absorbent and place it in an appropriate container for disposal. Flush trace residues with large amounts of water. Do not flush waste to sewers or open waterways. WASTE DISPOSAL: Consider reclamation, recycling, or destruction rather than disposal in a landfill. Waste may be burned in an approved incinerator equipped with an afterburner and a scrubber. Follow Federal, state, and local regulations.

Ethylene dichloride is designated as a hazardous substance by the EPA (40 CFR 116.4). Ethylene dichloride is reported in the 1983 EPA TSCA Inventory.

EPA Hazardous Waste Number (40 CFR 261.33): U077

EPA Reportable Quantity (40 CFR 117.3): 5000 lbs (2270 kgs)

Aquatic Toxicity Rating, TLm 96: 1000 - 100 ppm

SECTION 8. SPECIAL PROTECTION INFORMATION

GOGGLES: Always wear protective eyeglasses or chemical safety goggles. Ethylene dichloride is particularly harmful to the eyes, and direct contact results in corneal opacity (permanent clouding of the eye). GLOVES: Wear impervious rubber gloves to prevent skin contact. RESPIRATOR: Use a NIOSH-approved respirator per the NIOSH *Pocket Guide to Chemical Hazards* (Genium ref. 88) for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow the respirator guidelines in 29 CFR 1910.134. Any detectable concentration of ethylene dichloride requires an SCBA, full facepiece, and pressure-demand/positive-pressure modes. Warning: Air-purifying respirators will not protect workers from oxygen-deficient atmospheres. OTHER: Wear rubber boots, aprons, and other protective clothing suitable for use conditions to prevent skin contact. Remove contaminated clothing and launder it before wearing it again. Discard contaminated shoes. VENTILATION: Provide maximum explosion-proof local fume exhaust ventilation systems to maintain the airborne concentrations of ethylene dichloride vapors below the exposure limits cited in section 2. Install properly designed hoods that maintain a minimum face velocity of 100 lfm (linear feet per minute). SAFETY STATIONS: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling. SPECIAL CONSIDERATIONS: Vapors are heavier than air and will collect in low-lying areas. Eliminate sources of ignition in these areas and again provide good ventilation there. COMMENTS: Practice good personal hygiene. Keep materials off of your clothes and equipment. Avoid transferring this material from hands to mouth while eating, drinking, or smoking. Immediately remove ethylene dichloride-saturated clothing to avoid flammability and health hazards. Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

STORAGE SEGREGATION: Store ethylene dichloride in tightly closed containers in a cool, dry, well-ventilated area away from sources of ignition. Protect containers from physical damage and from exposure to excessive heat. Avoid direct physical contact with strong acids, bases, oxidizing agents, and reducing agents. SPECIAL HANDLING/STORAGE: Use nonsparking tools. Outside or detached storage is preferred. Store and handle ethylene dichloride in accordance with the regulations concerning OSHA class IB flammable liquids. ENGINEERING CONTROLS: During transfer operations involving ethylene dichloride, the liquid and its vapors must not be exposed to nearby sources of ignition from engineering systems that are not explosion proof. Preplan emergency response procedures.

TRANSPORTATION DATA (per 49 CFR 172.101-2):

DOT Hazard Class: Flammable Liquid

DOT Label: Flammable Liquid

IMO Class: 3.2

DOT Shipping Name: Ethylene Dichloride

DOT ID No. UN 1184

IMO Label: Flammable Liquid, Poison

References: 1-9, 12, 19, 21, 26, 43, 47, 73, 87-102. CK

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Approvals J.O. Accocco

Indust. Hygiene/Safety 11-18-87

Medical Review 11-30-87

VINYLIDENE CHLORIDE

VCI

Common Synonyms			
1, 1-Dichloroethylene unsym-Dichloroethylene	Watery liquid	Colorless	Sweet odor

Sinks in water. Flammable, irritating vapor is produced.
Boiling point is 88°F.

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
Evacuate area in case of large discharge
Isolate and remove discharged material
Notify local health and pollution control agencies

Fire

FLAMMABLE.
POISONOUS GAS IS PRODUCED IN FIRE.
Containers may explode in fire.
Flashback along vapor trail may occur
Vapor may explode if ignited in an enclosed area.
Wear self-contained breathing apparatus
Combat fires from safe distance or protected location
Extinguish with dry chemical, foam, or carbon dioxide
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

Water Pollution

Effect of low concentrations on aquatic life is unknown.
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-high flammability
Evacuate area.

2. LABEL

2.1 Category: Flammable liquid
2.2 Class: 3

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Vinyl halides
3.2 Formula: $CH_2=CCl_2$
3.3 IMO/UN Designation: 3.1/1303
3.4 DOT ID No.: 1303
3.5 CAS Registry No.: 75-35-4

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Colorless
4.3 Odor: Sweet; like carbon tetrachloride or chloroform

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Approved canister or air-supplied mask; goggles or face shield; rubber gloves and boots.
5.2 Symptoms Following Exposure: Vapor can cause dizziness and drunkenness; high levels cause anesthesia. Liquid irritates eyes and skin.
5.3 Treatment of Exposure: INHALATION: If any illness develops, remove person to fresh air promptly, keep warm and quiet, and get medical attention; if breathing stops, start artificial respiration. INGESTION: not likely a problem; no known antidote; treat symptomatically. EYES OR SKIN: flush with plenty of water for at least 15 min; get medical attention for eyes; remove contaminated clothing and wash before reuse.
5.4 Threshold Limit Value: 10 ppm
5.5 Short Term Inhalation Limits: Data not available
5.6 Toxicity by Ingestion: Grade 3; Oral LD_{50} = 24 hr = 84 mg/kg (adrenalectomized 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: Data not available
5.11 IDLH Value: Data not available

6. FIRE HAZARDS

6.1 Flash Point: 0°F O.C.
6.2 Flammable Limits in Air: 7.3%-16.0%
6.3 Fire Extinguishing Agents: Foam, carbon dioxide, dry chemical
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective.
6.5 Special Hazards of Combustion Products: Toxic hydrogen chloride and phosgene are generated in fires.
6.6 Behavior in Fire: May explode in fire due to polymerization. Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back.
6.7 Ignition Temperature: 955—1031°F
6.8 Electrical Hazard: Not pertinent
6.9 Burning Rate: 2.7 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: Copper and aluminum can cause polymerization.
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Can occur if exposed to sunlight, air, copper, aluminum, heat.
7.6 Inhibitor of Polymerization: 200 ppm methyl ether of hydroquinone; 0.6-0.8% phenol
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: 35

8. WATER POLLUTION

8.1 Aquatic Toxicity: Data not available
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: 99%
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: Padded
9.4 Venting: Pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)
A-X-Y-Z

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	3
Water Pollution	
Human Toxicity	0
Aquatic Toxicity	2
Aesthetic Effect	2
Reactivity	
Other Chemicals	2
Water	0
Self Reaction	3

11.3 NFPA Hazard Classification:

Category	Classification
Health Hazard (Blue)	1
Flammability (Red)	4
Reactivity (Yellow)	2

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 16°C and 1 atm: Liquid
12.2 Molecular Weight: 96.95
12.3 Boiling Point at 1 atm: 88.9°F = 31.6°C = 304.8°K
12.4 Freezing Point: —187.6°F = 122.0°C = 151.2°K
12.5 Critical Temperature: Not pertinent
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity: 1.21 at 20°C (liquid)
12.8 Liquid Surface Tension: 24 dynes/cm = 0.024 N/m at 15°C
12.9 Liquid Water Interfacial Tension: 37 dynes/cm = 0.037 N/m at 22.7°C
12.10 Vapor (Gas) Specific Gravity: 3.3
12.11 Ratio of Specific Heats of Vapor (Gas): Data not available
12.12 Latent Heat of Vaporization: 130 Btu/lb = 72 cal/g = 3.0 X 10^5 J/kg
12.13 Heat of Combustion: —4880 Btu/lb = —2700 cal/g = —113.0 X 10^5 J/kg
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: —333 Btu/lb = —185 cal/g = —7.75 X 10^5 J/kg
12.26 Heat of Fusion: Data not available
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: 16.3 psia

6. FIRE HAZARDS (Continued)

6.11 Stoichiometric Air to Fuel Ratio: Data not available
6.12 Flame Temperature: Data not available

1,2-DICHLOROETHYLENE

DEL

Common Synonyms

Acetylene dichloride
sym-dichloroethylene
Dioform
cis-1, 2-dichloroethylene
trans-1, 2-dichloroethylene

Liquid | Colorless | Sweet pleasant odor

Sinks in water. Flammable, irritating vapor is produced.

Wear goggles and self-contained breathing apparatus.
Shut off ignition sources. Call fire department.
Stop discharge if possible. Keep people away.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
POISONOUS GASES MAY BE PRODUCED IN FIRE.
Containers may explode in fire.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Extinguish with dry chemicals, foam or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID

VAPOR
If inhaled will cause dizziness, nausea, vomiting, or difficult breathing.
Move victim to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Harmful if swallowed.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
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-high flammability
Restrict access
Evacuate area
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: Not listed
3.2 Formula: $ClCH = CHCl$
3.3 BOD/UN Designation: 3.2/1150
3.4 DOT ID No.: 1150
3.5 CAS Registry No.: 540-59-0

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Colorless
4.3 Odor: Ethereal, slightly acrid; pleasant, chloroform-like

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Rubber gloves; safety goggles; air supply mask or self-contained breathing apparatus.
5.2 Symptoms Following Exposure: Inhalation causes nausea, vomiting, weakness, tremor, epigastric cramps, central nervous depression. Contact with liquid causes irritation of eyes and (on prolonged contact) skin. Ingestion causes slight depression to deep narcosis.
5.3 Treatment of Exposure: INHALATION: remove from further exposure; if breathing is difficult, give oxygen; if victim is not breathing, give artificial respiration, preferably mouth-to-mouth; give oxygen when breathing is resumed; call a physician. EYES: flush with water for at least 15 min. SKIN: wash well with soap and water. INGESTION: give gastric lavage and cathartics.
5.4 Threshold Limit Value: 200 ppm
5.5 Short Term Inhalation Limits: Data not available
5.6 Toxicity by Ingestion: Grade 2; oral LD_{50} = 770 mg/kg (rat)
5.7 Late Toxicity: Produces liver and kidney injury in experimental animals
5.8 Vapor (Gas) Irritant Characteristics: Data not available
5.9 Liquid or Solid Irritant Characteristics: Data not available
5.10 Odor Threshold: Data not available
5.11 IDLH Value: 4,000 ppm

6. FIRE HAZARDS

6.1 Flash Point: 37°F C.C.
6.2 Flammable Limits in Air: 9.7%-12.8%
6.3 Fire Extinguishing Agents: Dry chemical, foam, carbon dioxide
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective.
6.5 Special Hazards of Combustion Products: Phosgene and hydrogen chloride fumes may form in fires.
6.6 Behavior in Fire: Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back.
6.7 Ignition Temperature: 860°F
6.8 Electrical Hazard: Data not available
6.9 Burning Rate: 2.6 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: Will not occur under ordinary conditions of shipment. The reaction is not vigorous.
7.6 Inhibitor of Polymerization: None used
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: Data not available

8. WATER POLLUTION

8.1 Aquatic Toxicity: Data not available
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Commercial
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-X-Y

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Flammable liquid
11.2 NAS Hazard Rating for Bulk Water Transportation: Not listed
11.3 NFPA Hazard Classification:

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

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 97.0
12.3 Boiling Point at 1 atm:
cis: 140°F = 60°C = 333°K
trans: 118°F = 48°C = 321°K
12.4 Freezing Point:
cis: −114°F = −81°C = 192°K
trans: −58°F = −50°C = 223°K
12.5 Critical Temperature: Not pertinent
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity:
1.27 at 25°C (liquid)
12.8 Liquid Surface Tension:
24 dynes/cm = 0.024 N/m at 20°C
12.9 Liquid Water Interfacial Tension: (est.)
30 dynes/cm = 0.030 N/m at 20°C
12.10 Vapor (Gas) Specific Gravity: 3.34
12.11 Ratio of Specific Heats of Vapor (Gas): 1.1483
12.12 Latent Heat of Vaporization:
130 Btu/lb = 72 cal/g =
3.0×10^4 J/kg
12.13 Heat of Combustion: −4,847.2 Btu/lb = −2,692.9 cal/g = -112.67×10^4 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: Data not available

6. FIRE HAZARDS (Continued)

6.11 Stoichiometric Air to Fuel Ratio: Data not available
6.12 Flame Temperature: Data not available

OILS, FUEL: 1-D

OOD

Common Synonyms			
Diesel oil (light)	Oily liquid Floats on water	Yellow-brown	Lube or fuel oil odor

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

Fire

Combustible
Extinguish with dry chemical, foam or carbon dioxide
Water may be ineffective on fire
Cool exposed containers with water

Exposure

CALL FOR MEDICAL AID

LIQUID
Irritating to 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

Dangerous to aquatic life in high 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: None
2.2 Class: Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Miscellaneous Hydrocarbon Mixtures
3.2 Formula: Not applicable
3.3 IMO/UN Designation: 3.1/1270
3.4 DOT ID No.: 1270
3.5 CAS Registry No.: Data not available

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Light brown
4.3 Odor: Characteristic

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Protective gloves, goggles or face shield.
5.2 Symptoms Following Exposure: INHALATION causes headache and slight giddiness. INGESTION causes nausea, vomiting, and cramping; depression of central nervous system ranging from mild headache to anesthesia, coma, and death; pulmonary irritation secondary to exhalation of solvent; signs of kidney and liver damage may be delayed. ASPIRATION causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema, later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression.
5.3 Treatment of Exposure: INGESTION: do NOT induce vomiting, seek medical attention. ASPIRATION: enforce bed rest; administer oxygen. EYES: wash with copious quantity of water. SKIN: remove solvent by wiping and wash with soap and water.
5.4 Threshold Limit Value: No single value applicable
5.5 Short Term Inhalation Limits: Data not available
5.6 Toxicity by Ingestion: Grade 1, LD_{50} = 5-15 g/kg
5.7 Late Toxicity: Data not available
5.8 Vapor (Gas) Irritant Characteristics: Slight smarting of eyes or respiratory system if present in high concentrations. The effect is temporary.
5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin.
5.10 Odor Threshold: 0.7 ppm
5.11 IDLH Value: Data not available

6. FIRE HAZARDS

6.1 Flash Point: 100°F C.C.
6.2 Flammable Limits in Air: 1.3%-6%
6.3 Fire Extinguishing Agents: Dry chemical, foam, or carbon dioxide
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective.
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Not pertinent
6.7 Ignition Temperature: 350—625°F
6.8 Electrical Hazard: Not pertinent
6.9 Burning Rate: 4 mm/min.
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: 33

8. WATER POLLUTION

8.1 Aquatic Toxicity:
204 mg/1/24 hr/juvenile American shad/Tl. $_{50}$/salt water
8.2 Waterfowl Toxicity: 20 mg/kg LD_{50} (mallard)
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Diesel fuel 1-D (ASTM)
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Open (flame arrester)

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-T-U

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Combustible liquid
11.2 NAS Hazard Rating for Bulk Water Transportation: Not listed
11.3 NFPA Hazard Classification:

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

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: Not pertinent
12.3 Boiling Point at 1 atm: 380—560°F = 193—293°C = 466—566°K
12.4 Freezing Point: —30°F = —34°C = 240°K
12.5 Critical Temperature: Not pertinent
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity: 0.81—0.85 at 15°C (liquid)
12.8 Liquid Surface Tension: 23—32 dynes/cm = 0.023—0.032 N/m at 20°C
12.9 Liquid Water Interfacial Tension: 47—48 dynes/cm = 0.047—0.049 N/m at 20°C
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: 110 Btu/lb = 60 cal/g = 2.5 X 10^4 J/kg
12.13 Heat of Combustion: —18,540 Btu/lb = —10,300 cal/g = —431.24 X 10^4 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: Data not available

NOTES

OILS, FUEL: 2-D

OTD

Common Synonyms	Oily liquid	Yellow-brown	Lube or fuel oil odor
Diesel oil, medium	Floats on water		

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

Fire

Combustible.
Extinguish with dry chemical, foam, carbon dioxide
Water may be ineffective on fire
Cool exposed containers with water

Exposure

CALL FOR MEDICAL AID

LIQUID
Irritating to 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

Dangerous to aquatic life in high 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: None
2.2 Class: Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Miscellaneous Hydrocarbon Mixtures
3.2 Formula: Not applicable
3.3 IMO/UN Designation: 3 1/1270
3.4 DOT ID No.: 1270
3.5 CAS Registry No.: Data not available

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Light brown
4.3 Odor: Characteristic

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Protective gloves; goggles or face shield.
5.2 Symptoms Following Exposure: INGESTION causes nausea, vomiting, and cramping; depression of central nervous system ranging from mild headache to anesthesia, coma, and death; pulmonary irritation secondary to exhalation of solvent; signs of kidney and liver damage may be delayed. ASPIRATION causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression.
5.3 Treatment of Exposure: INGESTION: do NOT induce vomiting. ASPIRATION: enforce bed rest; administer oxygen; seek medical attention. EYES: wash with copious quantity of water. SKIN: remove solvent by wiping and wash with soap and water
5.4 Threshold Limit Value: No single TLV applicable
5.5 Short Term Inhalation Limits: Data not available
5.6 Toxicity by Ingestion: Grade 1. LD_{50} = 5-15 g/kg
5.7 Late Toxicity: Data not available
5.8 Vapor (Gas) Irritant Characteristics: Slight smarting of eyes or respiratory system if present in high concentrations. The effect is temporary
5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin
5.10 Odor Threshold: Data not available
5.11 IDLH Value: Data not available

6. FIRE HAZARDS

6.1 Flash Point: 125°F C.C.
6.2 Flammable Limits in Air: 1.3%-6.0%
6.3 Fire Extinguishing Agents: Dry chemical, foam, or carbon dioxide
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Not pertinent
6.7 Ignition Temperature: 490—545°F
6.8 Electrical Hazard: Not pertinent
6.9 Burning Rate: 4 mm/min.
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: 33

8. WATER POLLUTION

8.1 Aquatic Toxicity: 204 mg/l/24 hr/juvenile American shad/TL_m/salt water
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Diesel fuel 2-D (ASTM)
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Open (flame arrester)

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-T-U

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Combustible liquid
11.2 NAS Hazard Rating for Bulk Water Transportation: Not listed
11.3 NFPA Hazard Classification:

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

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: Not pertinent
12.3 Boiling Point at 1 atm: 540—640°F = 282—338°C = 555—611°K
12.4 Freezing Point: 0°F = 18°C = 255°K
12.5 Critical Temperature: Not pertinent
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity: 0.87—0.90 at 20°C (liquid)
12.8 Liquid Surface Tension: Data not available
12.9 Liquid Water Interfacial Tension: Data not available
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: —19,440 Btu/lb = —10,800 cal/g = —452.17 X 10^4 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: Data not available

NOTES

Genium Publishing Corporation
1145 Catalyn Street, Schenectady, NY 12303
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Product: AUTOMOTIVE GASOLINE, LEAD FREE

MSDS No: Genium / 467
Date: October, 1981

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: AUTOMOTIVE GASOLINE, LEAD FREE

Description: A volatile blend of hydrocarbons for automotive fuel.

Other Designations: Petrol, ASTM D439

CAS: 008 006 619

Available from several suppliers.

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	Percent:	Exposure Limits:
Gasoline	100%	8-hr TWA 300 ppm or 900 mg/m^3 Man: Eye: 500 ppm/1H Moderate irritation Inhalation: TCLo 900 ppm/1H TFX:CNS

A hydrocarbon blend that can include normal and branched chain alkanes, cycloalkanes, alkenes, aromatics and other additives.** (Lead max 0.013 g/L, phosphorus max 0.0013 g/L, sulfur max 0.10 wt%. May contain benzene, <5%; see ASTM D3606).
*ACGIH 1981 TLV (Intended Changes List). See also Am. Ind. Hyg. A. 39 110-117 (1978)

**The composition of fuel is varied with altitude and seasonal requirements for a locality. The blend must meet antiknock requirements. (Antiknock Index min 85, ASTM D439.)

SECTION III. PHYSICAL DATA

Appearance & Odor: A clear, mobile liquid with a characteristic odor which can be recognized at about 10 ppm in air. (Gasoline may be colored with dye.)

Water solubility (%): Insoluble
Vapor density (air=1): 3.0-4.0

Evaporation rate: N/A
Specific gravity (H_2O=1): 0.72-0.76 @ 60/60°F
Melting point: -90.5-95.4

Distillation at 1 atm, Initial, deg C > 39
50% distilled - 77-121
End point ----- <240

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Material Safety Data Sheet

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Date: October, 1981

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point (method): -45°F Limits: LEL %: 1.4 UEL %: 7.6

Extinguishing Media: Dry chemical, carbon dioxide, alcohol foam. Use of water may be ineffective to extinguish fire, but use water spray for cooling fire-exposed drums and tanks to prevent pressure rupture.

Autoignition Temp: 536-853°F

Unusual fire or explosion hazards: It is a dangerous fire and explosion hazard when exposed to heat and flames. Vapors can flow along surfaces, reach distant ignition sources and flash back. Can react violently with oxidizing agents.

Special fire-fighting procedures: Firefighters should wear self-contained breathing apparatus and full protective clothing.

Flammability Limits In Air: % by volume

SECTION V. REACTIVITY DATA

Material is stable in closed containers at room temperature under normal storage and handling conditions. Hazardous polymerization cannot occur

Chemical incompatibilities: It is incompatible with oxidizing agents.

Conditions to avoid: A mixture of gasoline vapors and air can be explosive.

This is an OSHA Class IA flammable liquid.
Thermal-oxidative degradation can yield carbon monoxide and partially oxidized hydrocarbons.

SECTION VI. HEALTH HAZARD INFORMATION

Summary of risks: Inhalation causes intense burning of the mucous membranes, throat and respiratory tract; overexposure to vapors can lead to bronchopneumonia. Inhalation of high conc. can cause fatal pulmonary edema. Repeated or prolonged skin exposure causes dermatitis. Can cause blistering of skin due to its defatting properties. Exposure to eyes can cause hyperemia of the conjunctiva. Ingestion or excessive vapors can cause inebriation, drowsiness, blurred vision, vertigo, confusion, vomiting and cyanosis (2000 ppm produces mild anesthesia in 30 min., higher conc. are intoxicating in less time.) Aspiration after ingestion causes bronchitis, pneumonia, or edema which can be fatal.

 HEALTH HAZARD INFORMATION continues on page 3

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HEALTH HAZARD INFORMATION continued from page 2

First aid:

Eye contact: Flush thoroughly with running water for 15 minutes including under eyelids.

Skin contact: Remove contaminated clothing. Wash affected area with soap and water.

Inhalation: Remove to fresh air. Restore breathing and administer oxygen if needed.

Ingestion: Do not induce vomiting. Aspiration hazard. Contact physician.

Seek prompt medical assistance for further treatment, observation and support.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Notify safety personnel of leaks or spills. Remove sources of heat or ignition. Provide adequate ventilation. Clean-up personnel require protection against liquid contact and vapor inhalation. If a leak or spill has not ignited, use water spray to disperse vapors and to protect men attempting to stop the leakage. Contain spill. Do not allow to enter sewer or surface water. Add absorbent solid to small spills or residues and pick up for disposal.

Waste management / Disposal: Burn scrap material in an approved incinerator. Burn contaminated liquid by spraying into an incinerator. Follow Federal, State, and Local regulations.

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:

Goggles: Avoid eye contact by use of chemical safety goggles and/or full faceshield where splashing is possible.

Gloves: Wear protective clothing appropriate for the work situation to minimize skin contact such as rubber gloves and boots.

Respirator: Respirators should be available for nonroutine or emergency use above the TLV.

Other: Clothing to be changed daily and laundered.

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Date: October, 1981

SPECIAL PROTECTION INFORMATION continued from page 3

Workplace considerations:

Ventilation: Use general and local exhaust ventilation (explosion-proof) to keep vapors below the TLV requirements in the workplace.

Safety stations:
Eyewash fountains, showers, and washing facilities should be readily available.

Provide suitable training to those handling and working with this material.

SECTION IX. SPECIAL PRECAUTIONS

Storage segregation: Store in closed containers in a cool, dry, well-ventilated area away from sources of heat, ignition and strong oxidizing agents. Protect containers from physical damage. Avoid direct sunlight. Storage must meet requirements of OSHA Class IA liquid.
Outdoor or detached storage preferred. No smoking in areas of use. Prevent static electric sparks and use explosion-proof electrical services. (Must meet code).

Other precautions: Avoid skin and eye contact. Avoid inhalation of vapors. Wear clean work clothing daily. Indoor use of this material requires exhaust ventilation to remove vapors.

ICC Flammable Liquid, Red Label. LABEL: Flammable Liquid

DOT Class: FLAMMABLE LIQUID UN Register: UN1203
Data source code(s): 2, 4-9, 34, 37. N

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Product: PERCHLOROETHYLENE

MSDS No: Genium / 313
Revision: C
Date: November, 1978

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: PERCHLOROETHYLENE

Other Designations: Perchlorethylene, Tetrachloroethylene, Ethylene Tetrachloride, $Cl_2C=CCl_2$, GE Material D5B84

CAS: 000 127 184

TRADE NAME (MANUFACTURERS): BLACO-PER (Baron-Blakeslee); PERCHLOR (PPG); PERK (Stauffer); PERCLENE (Diamond Shamrock)

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	Percent:	Exposure Limits:
Perchloroethylene plus stabilizer*	ca 100	8-hr TWA 100 ppm** with 200 ppm Ceiling and 300 ppm 5 minute peak in any 3 hrs. Rat, Inhalation: LCLo 4000 ppm/4 hrs.

* Stablized material usually contains a small amount of amine and/or phenolic stabilizer. Stabilizers and levels used vary with the grade and the supplier.
** Current OSHA levels. ACGIH TLV (1978) is 100 ppm (skin). In 1976 NIOSH approved a 10-hr TWA of 50 ppm with a 100 ppm ceiling (15 min. sample).

NIOSH (1978) has warned of possible carcogenicity based on animal tests.

SECTION III. PHYSICAL DATA

Appearance & Odor: Colorless liquid with pleasant etheral odor whose recognition threshold (100% of test panel, unfatigued) is 4.68 ppm in air.

Boiling point: 250°F (121°C), 1 atm
Vapor pressure: 15.8 @ 22°C, mm Hg
Water solubility (%): Negligible
Vapor density (air=1): 5.83
Evaporation rate: 0.27 (CCl_4=1)
Specific gravity (H_2O=1): 1.623 @ 20/4°C
% volatile by volume: ca 100
Molecular weight: 165.83

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MSDS No: Genium / 313
Revision: C
Date: November, 1978

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point (method): Not Combustible **Limits: LEL %:** N/A **UEL %:** N/A

Extinguishing Media: Use that which is suitable for the surrounding fire. **Autoignition Temp:** NONE

Unusual fire or explosion hazards: Although not combustible, perchloroethylene can be hazardous in a fire situation because of vapor generation and from thermo-oxidative degradation at high temperature to phosgene (highly toxic) and hydrogen chloride (corrosive).

Special fire-fighting procedures: Firefighters should use self-contained breathing apparatus when this material is involved in a fire situation.

SECTION V. REACTIVITY DATA

Material is stable under normal storage and handling conditions.

Chemical incompatibilities: Avoid mixing with caustic soda or potash. Do not allow hydrochloric acid build-up to occur in degreasing tanks (stabilizer exhausted).

Hazardous decomposition Products: Vapor exposure to high temperature or electric arcs may cause decomposition to hydrogen chloride and phosgene (highly toxic).

Prolonged exposure to sunlight (UV) can degrade unstabilized material.

SECTION VI. HEALTH HAZARD INFORMATION

Summary of risks: Perchloroethylene may cause dermatitis through prolonged or repeated skin contact with liquid and irritation, lachrymation, and burning sensation of the eyes by liquid or vapor contact. Loss of coordination, narcosis, tremors, abdominal cramps, irritation of the respiratory tract, and nausea may result from inhalation of excessive airborne concentrations. (600 ppm for 10 minutes may affect the central nervous system.) Very high exposures produce unconsciousness and even death.

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HEALTH HAZARD INFORMATION continued from page 2

First aid:

Eye contact: Wash eyes with copious amounts of running water to relieve irritation.

Skin contact: Remove contaminated clothes. Wash exposed skin with soap and water.

Inhalation: Remove patient to fresh air; restore breathing if necessary. Promptly contact physician. Advise doctor not to administer adrenalin.

Ingestion: If taken internally, induce vomiting. Contact physician promptly; advise doctor not to administer adrenalin.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Supply maximum ventilation. Confine spill to small area; do not allow run off into sewer. Those involved in clean-up need protection from liquid contact and vapor inhalation. Pick up spill on absorbent solid.

Waste management / Disposal: Place in covered container for disposal. Chlorinated solvents in large amounts should be burned in an approved incinerator with appropriate fume scrubbing. Also, consult licensed waste disposal company in your locality and consider recovery of perchloroethylene solvent by distillation. Scrap solvent and distillation residues must be handled as toxic waste. Follow Federal, State and Local regulations for waste disposal.

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:

Goggles: Appropriate eye and face protection should be used.

Gloves: Neoprene, Viton, PVA or PVC coated gloves should be used to prevent skin exposure.

Respirator: For emergency and non-routine exposure above the TLV approved full facepiece respirators should be used - cartridge and canister types up to 500 ppm, and air-supplied or self-contained types above 500 ppm.

Other: Where splashing is possible, aprons and protective clothing may be indicated.

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SPECIAL PROTECTION INFORMATION continued from page 3

Workplace considerations:

Ventilation: Airborne levels should be kept below TLV levels by use of general ventilation and local exhaust ventilation. Provide floor level ventilation to remove these vapors.

Where eye contamination is possible, an eye wash fountain should be readily available.

SECTION IX. SPECIAL PRECAUTIONS

Storage segregation: Store in a cool, dry, well-ventilated place in closed containers away from fire hazards. High temperature (700°C) or intense UV light can decompose perchloroethylene to toxic and corrosive materials. Smoking, open flame, welding, etc. should not be permitted in area of use or storage.

Other precautions: It is recommended that workers with blood pressure, heart, liver, kidney or pulmonary problems, with nervous system disorders, with excessive obesity, or with alcohol consumption problems should not work in proximity to this or other chlorinated solvents.
One study has indicated possible teratogenic effects. NIOSH has recommended that this material be handled as if it were a human carcinogen. (Current Intelligence Bulletin No. 20, 1978)

Data source code(s): 1-9, 12, 21. N

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Material Safety Data Sheet

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Product: TRICHLOROETHYLENE

MSDS No: Genium / 312
Revision: E
Date: August, 1987

National Paint and Coatings Association Hazardous Material Identification System		
	HEALTH HAZARD	2 - Moderate
	FLAMMABILITY HAZARD	1 - Slight
	REACTIVITY HAZARD	1 - Slight
	PERSONAL PROTECTION	SEE SECTION 8

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: TRICHLOROETHYLENE

Description: Prepared from sym-tetrachloroethane by way of eliminating HCl by boiling with lime. Used to manufacture organic chemicals, pharmaceuticals; in degreasing and dry cleaning; and as a solvent for fats, waxes, rubbers, oils, paints, varnishes, ethers, and cellulose esters.

Other Designations: Ethylene Trichloride; TCE; Trichloroethene; 1,1,2-Trichloroethylene; C_2HCl_3; NIOSH RTECS #KX4550000

CAS: 0079-01-6

R 1
I 3
S 1
K 0

COMMENTS: Trichloroethylene is a toxic solvent and a suspected occupational carcinogen.

Available from several suppliers, including:

Manufacturer: Dow Chemical USA
2020 Dow Center
Midland, MI 48640

Phone: (517) 636-1000; (800) 258-CHEM

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	CAS Number:	Percent:	Exposure Limits:
Trichloroethylene	0079-01-6	100	ACGIH Values 1987-88 TLV-TWA*: 50 ppm, 270 mg/m^3 TLV-STEL**: 200 ppm, 1080 mg/m^3

 INGREDIENTS AND HAZARDS continues on page 2

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INGREDIENTS AND HAZARDS continued from page 1

OSHA PEL 1986***
8-Hr TWA: 100 ppm
Ceiling: 200 ppm
NIOSH REL 1986
10-Hr TWA: 25 ppm
TOXICITY DATA
Human, Oral, LD_{Lo}: 7 g/kg
Human, Inhalation, TC_{Lo}: 6900 mg/m^3 (10 Min)
Human, Inhalation, TC_{Lo}: 160 ppm/83 Min
Human, Inhalation, TD_{Lo}: 812 mg/kg

NIOSH RTECS #KX4550000

* The TLV-TWA is set to control subjective complaints such as headache, fatigue, and irritability.

** The TLV-STEL is set to prevent incoordination and other beginning anesthetic effects from trichloroethylene. These levels should provide a wide margin of safety in preventing liver injury.

*** The OSHA PEL is 300 ppm for 5 minutes in any 2 hours.

SECTION III. PHYSICAL DATA

Appearance & Odor: Colorless, nonflammable mobile liquid; sweetish odor like chloroform.

Boiling point: 188.6°F (87°C)
Vapor pressure: 58 Torr at 68°F (20°C)
Water solubility (%): Insoluble
Vapor density (air=1): 4.53
Evaporation rate: Not Listed
Specific gravity (H_2O=1): 1.4649 at 68°F (20°C)
Melting point: -120.64°F (-84.8°C)
Molecular weight: 131.40 Grams/Mole

COMMENTS: Trichloroethylene is highly soluble in lipids. A high vapor pressure at room temperature provides the potential for trichloroethylene vapors to contaminate use areas.

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MSDS No: Genium / 312
Revision: E
Date: August, 1987

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point (method): Not Listed Limits: LEL %: 8 UEL %: 10.5

Extinguishing Media: Trichloroethylene has no flash point in a conventional closed tester at room temperature, but it is moderately flammable at higher temperatures. Use dry chemical, carbon dioxide, alcohol foam, or other extinguishing agents suitable for the surrounding fire.

Autoignition Temp: 770°F (410°C)

OSHA Flammability Class (29 CFR 1910.106): Not Regulated

Unusual fire or explosion hazards: During fire conditions trichloroethylene emits highly toxic and irritating fumes, including hydrochloric acid and phosgene.

Special fire-fighting procedures: Wear a self-contained breathing apparatus with a full facepiece operated in a pressure-demand or another positive-pressure mode. At trichloroethylene vapor levels of 300-1000 ppm, fire fighters who lack the proper respiratory equipment may experience incoordination and impaired judgment.

DOT Flammability Class (49 CFR 173.115): Not Regulated

SECTION V. REACTIVITY DATA

Material is stable Hazardous polymerization can occur under certain circumstances (see Conditions to Avoid and Comments, below).

Chemical incompatibilities: Include magnesium or aluminum powder, NaOH, KOH, or other strong alkaline materials. Reactions with alkaline materials may lead to the formation of dangerous explosive mixtures of chloroacetylenes.

Conditions to avoid: When trichloroethylene is heated (as in the case with vapor degreasers) or exposed to sunlight, it requires extra stabilization against oxidation, degradation, and polymerization. It is slowly decomposed by light when moist.

Hazardous decomposition Products: Include hydrochloric acid and phosgene under certain conditions at elevated temperatures.

COMMENTS: Trichloroethylene is stable under normal handling and storage conditions, and hazardous polymerization is not expected to occur. However, failure of the stabilizer at elevated temperatures or other extreme conditions may allow polymerization to occur.

 MSDS 312 continues on page 4

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Product: TRICHLOROETHYLENE

MSDS No: Genium / 312
Revision: E
Date: August, 1987

SECTION VI. HEALTH HAZARD INFORMATION

This product is considered a carcinogen by the NTP, IARC, and OSHA.**

Summary of risks: Moderate exposures to trichloroethylene cause symptoms similar to those of alcohol inebriation. Higher concentrations cause narcotic effects. Ventricular fibrillation has been cited as the cause of death following heavy exposures. Trichloroethylene-induced hepato cellular carcinomas have been detected in mice during tests conducted by the National Cancer Institute (Chem & Eng News 54 [April 5, 1976]:4). Organ systems affected by overexposure to trichloroethylene are the central nervous system (euphoria, analgesia, anesthesia), degeneration of the liver and kidneys, the lungs (tachypnea), heart (arrhythmia) and skin (irritation, vesication, and paralysis of fingers when immersed in liquid trichloroethylene). Contact with the liquid defats the skin, causing topical dermatitis. Certain people appear to experience synergistic effects from trichloroethylene exposure concomitant with exposure to caffeine, alcohol, and other drugs. ***

Medical conditions which may be aggravated by contact: Diseases of the liver, kidneys, lungs, and central nervous system.

Target organs: Respiratory system, central nervous system, heart, liver, kidneys, and skin.

Primary entry route(s): Ingestion, inhalation, skin contact.

Acute effects: Headache, vertigo, visual disturbance, tremors, nausea, vomiting, dermatitis, dizziness, drowsiness, and irritation to the eyes, nose, and throat.

Chronic effect(s): None Reported

First aid:

Eye contact: Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. Get medical help.*

Skin contact: Wash thoroughly with soap and water. Remove and launder contaminated clothing before wearing it again; clean material from shoes and equipment. Get medical help.*

Inhalation: Remove victim to fresh air; restore and/or support his breathing as needed. Do not give adrenalin to the victim. Get medical help.*

Ingestion: Call a poison control center. Never give anything by mouth to someone who is unconscious or convulsing. A professional decision regarding whether or not to induce vomiting is required. Do not give adrenalin to the victim. Get medical help.*

* GET MEDICAL ASSISTANCE = IN PLANT, PARAMEDIC, COMMUNITY. Get prompt medical assistance for further treatment, observation, and support after first aid.

 HEALTH HAZARD INFORMATION continues on page 5

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HEALTH HAZARD INFORMATION continued from page 4

** NIOSH recommends that trichloroethylene be treated as an occupational carcinogen. IARC carcinogenic results are animal suspect, animal positive, and human indefinite.

*** When combined with alcohol intake, toxic effects are increased and may cause a red, blotchy facial and upper body rash commonly called "degreaser's flush." Other reported symptoms of trichloroethylene exposure include abnormal fatigue, headache, irritability, gastric disturbances, and intolerance to alcohol. Toxic effects from testing of trichloroethylene on humans include hallucination, distorted perception, somnolence (general depressed activity), and jaundice.

COMMENTS: See Section 9 Comments

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Inform safety personnel of any trichloroethylene spill or leak and evacuate the area for large spills. Cleanup personnel must use respiratory and liquid contact protection. Adequate ventilation must be provided. Confine the spilled trichloroethylene to as small an area as possible. Do not allow it to run off to sewers or open waterways. Pick up spilled trichloroethylene with a vacuum cleaner or an absorbent such as vermiculite.

Waste management / Disposal: Consider reclamation, recycling, or destruction rather than disposal in a landfill.

Trichloroethylene is designated as a hazardous substance by the EPA (40 CFR 116.4).

Trichloroethylene is reported in the 1983 EPA TSCA Inventory.

EPA Hazardous Waste Number (40 CFR 261.33): U228

EPA Reportable Quantity (40 CFR 117.3): 1000 lbs (454 kgs)

Aquatic Toxicity Rating, TLm 96: Not Listed

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:

Goggles: Always wear protective eyeglasses or chemical safety goggles. Follow the eye- and face-protection guidelines of 29 CFR 1910.133.

Gloves: Wear impervious gloves.

 SPECIAL PROTECTION INFORMATION continues on page 6

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Product: TRICHLOROETHYLENE

MSDS No: Genium / 312
Revision: E
Date: August, 1987

SPECIAL PROTECTION INFORMATION continued from page 5

Respirator: Use a NIOSH-approved respirator per the NIOSH Guide to Chemical Hazards (Genium ref. 88) for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow the respirator guidelines in 29 CFR 1910.134. Any detectable concentration of trichloroethylene requires an SCBA, full facepiece, and pressure-deficient atmospheres.

Other: Wear rubber boots, aprons, and other suitable body protection appropriate to the existing work environment.

Workplace considerations:

Ventilation: Install and operate general and local exhaust ventilation systems of sufficient power to maintain airborne concentrations of trichloroethylene below the OSHA PEL standards cited in section 2.

Safety stations:
Make eyewash stations, washing facilities, and safety showers available in areas of use and handling.

Contaminated equipment:
Cotnact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.

Other: Because of the unresolved controversy about the carcinogenic status of trichloroethylene, all existing personal protective equipment and engineering technology should be used to prevent any possibility of worker contact with this material.

COMMENTS: Practice good personal hygiene. Keep material off of your clothes and equipment. Avoid transfer of material from hands to mouth while eating, drinking, or smoking. Adhere to the sanitation requirements of 29 CFR 1910.141 and 29 CFR 1910.142.

SECTION IX. SPECIAL PRECAUTIONS

Storage segregation: Prevent trichloroethylene from coming into contact with strong caustics such as NaOH; KOH; chemically active metal like Ba, Li, Na, Mg, Ti; and powdered aluminum or magnesium in acidic solutions.

Special handling / storage: Store this material in a cool, dry, well-ventilated area. Avoid elevated temperatures because products of toxic and corrosive decomposition from trichloroethylene may form. Monitor the level of any stabilizer component that may be added to the trichloroethylene. (Consult the technical data from the supplier to determine the specifics of any added stabilizer.) If applicable, follow the supplier's recommendation concerning proper rotation of stock, shelf-life requirements, and levels of stabilizers.

Engineering controls: Avoid collecting aluminum fines (very small particles) or chips in a trichloroethylene vapor degreaser. Monitor trichloroethylene stabilizer levels

 SPECIAL PRECAUTIONS continues on page 7

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MSDS No: Genium / 312
Revision: E
Date: August, 1987

SPECIAL PRECAUTIONS continued from page 6

regularly. Only trained personnel should operate vapor degreasers.

COMMENTS: (Comments from Section 6) Workers' responses to trichloroethylene vary significantly because of many factors, including age, health status, nutrition, and intake of alcohol, caffeine, and medicines. Do not use these substances before, during, or after exposure to trichloroethylene. If a worker displays any of the symptoms of exposure to trichloroethylene, thoroughly investigate all the possible contributing factors to determine, if possible, how much the work environment levels of trichloroethylene are responsible.

TRANSPORTATION DATA (per 49 CFR 172.101-2):
IMO Class: 6.1
IMO Label: St. Andrew's Cross (X)*
DOT Shipping Name: Trichloroethylene
DOT Label: None

* Harmful - Stow away from foodstuffs (IMO Label, Materials of Class 6.1 Packaging Group III).

DOT Class: ORM-A UN Register: UN1710
Data source code(s): 1-9, 12, 14, 21, 73, 87-94. PI

Prepared/revised by: Genium Publishing Corporation

August, 1987

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Material Safety Data Sheet

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Product: TOLUENE

MSDS No: Genium / 317
Revision: D
Date: April, 1986

National Paint and Coatings Association Hazardous Material Identification System		
	HEALTH HAZARD	2 - Moderate
	FLAMMABILITY HAZARD	3 - Serious
	REACTIVITY HAZARD	0 - Minimal
	PERSONAL PROTECTION	SEE SECTION 8

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: TOLUENE

Other Designations: Methyl Benzene, Methyl Benzol, Phenylmethane, Toluol, C_7H_8

CAS: 0108-88-3

Available from many suppliers, including:

Manufacturers: Allied Corp.
PO Box 2062R
Morristown, NJ 07960

Phone: (201) 455-4400

Ashland Chemical Co.
Industrial Chemicals & Solvents Div.

PO Box 2219
Columbus, OH 43216

Phone: (614) 889-3844

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	Percent:	Exposure Limits:
Toluene	ca 100	8-hr TLV: 100 ppm, or 375 mg/m^3* (Skin) **
		Man, Inhalation, TCLo: 100 ppm: Psychotropic ***
		Rat, Oral LD$_{50}$: 5000 mg/kg Rat, Inhalation, LCLo: 4000 ppm/4 hrs.

 INGREDIENTS AND HAZARDS continues on page 2

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INGREDIENTS AND HAZARDS continued from page 1

	Rabbit, Skin, LD_{50}: 14 gm/kg
	Human, Eye: 300 ppm

* Current (1985-86) ACGIH TLV. The OSHA PEL is 200 ppm with an acceptable ceiling concentration of 300 ppm and an acceptable maximum peak of 500 ppm/10 minutes.

** Skin designation indicates that toluene can be absorbed through intact skin and contribute to overall exposure.

*** Affects the mind.

SECTION III. PHYSICAL DATA

Appearance & Odor: Clear, colorless liquid with a characteristic aromatic odor. The odor is detectable to most individuals in the range of 10 to 15 ppm. Because olfactory fatigue occurs rapidly upon exposure to toluene, odor is not a good warning property.

Boiling point: 231°F (111°C)	**Evaporation rate:** (BuAc=1): 2.24
Vapor pressure: @ 20°C, mm Hg: 2	**Specific gravity (H_2O=1):** 0.866
Water solubility (%): @ 20°C, wt.%: 0.05	**Melting point:** -139°F (-95°C)
Vapor density (air=1): 3.14	**% volatile by volume:** ca 100
	Molecular weight: 92.15

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point (method): 40°F (4°C) CC **Limits: LEL %:** 1.27 **UEL %:** 7.1

Extinguishing Media: Carbon dioxide, dry chemical, alcohol foam. Do not use a solid stream of water because the stream will scatter and spread the fire. Use water spray to cool tanks/containers that are exposed to fire and to disperse vapors.

Autoignition Temp: 896°F (480°C)

Unusual fire or explosion hazards: This OSHA class IB flammable liquid is a dangerous fire hazard. It is a moderate fire hazard when exposed to oxidizers, heat, sparks, or open flame. Vapors are heavier than air and may travel a considerable distance to an ignition source and flash back.

Special fire-fighting procedures: Fire fighters should wear self-contained breathing apparatus with full facepiece operated in a positive-pressure mode when fighting fires involving toluene.

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Date: April, 1986

SECTION V. REACTIVITY DATA

Material is stable in closed containers at room temperature under normal storage and handling conditions. Hazardous polymerization does not occur

Chemical incompatibilities: This material is incompatible with strong oxidizing agents, dinitrogen tetraoxide, silver perchlorate, tetranitromethane, and uranium hexafluoride. Contact with these materials may cause fire or explosion. Nitric acid and toluene, especially in the presence of sulfuric acid, will produce nitrated compounds that are dangerously explosive.

Conditions to avoid: Avoid exposure to sparks, open flame, hot surfaces, and all sources of heat and ignition. Toluene will attack some forms of plastics, rubber, and coatings. Thermal decomposition or burning produces carbon dioxide and/or carbon monoxide.

SECTION VI. HEALTH HAZARD INFORMATION

This product is not considered a carcinogen by the NTP, IARC, or OSHA.

Summary of risks: Vapors of toluene may cause irritation of the eyes, nose, upper respiratory tract, and skin. Exposure to 200 ppm for 8 hours causes mild fatigue, weakness, confusion, lacrimation (tearing), and paresthesia (a sensation of prickling, tingling, or creeping on the skin that has no objective cause). Exposure to higher concentrations may cause headache, nausea, dizziness, dilated pupils, and euphoria, and, in severe cases, may cause unconsciousness and death. The liquid is irritating to the eyes and skin. Contact with the eyes may cause transient corneal damage, conjunctival irritation, and burns if not promptly removed. Repeated and/or prolonged contact with the skin may cause drying and cracking. It may be absorbed through the skin in toxic amounts. Ingestion causes irritation of the gastrointestinal tract and may cause effects resembling those from inhalation of the vapor. Chronic overexposure to toluene may cause reversible kidney and liver injury.

First aid:

Eye contact: Immediately flush eyes, including under eyelids, with running water for at least 15 minutes. Get medical attention if irritation persists.*

Skin contact: Immediately flush skin (for at least 15 minutes) while removing contaminated shoes and clothing. Wash exposed area with soap and water. Get medical attention if irritation persists or if a large area has been exposed. *

Inhalation: Remove victim to fresh air. Restore and/or support breathing as required. Keep victim warm and quiet. Get medical help.*

 HEALTH HAZARD INFORMATION continues on page 4

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MSDS No: Genium / 317
Revision: D
Date: April, 1986

HEALTH HAZARD INFORMATION continued from page 3

Ingestion: Give victim 1 to 2 glasses of water or milk. Contact a poison control center. Do not induce vomiting unless directed to do so. Transport victim to a medical facility. Never give anything by mouth to a person who is unconscious or convulsing.

* GET MEDICAL ASSISTANCE = In plant, paramedic, community. Get medical help for further treatment, observation, and support after first aid, if indicated.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Notify safety personnel of large spills or leaks. Remove all sources of heat and ignition. Provide maximum explosion-proof ventilation. Limit access to spill area to necessary personnel only. Remove leaking containers to safe place if feasible. Cleanup personnel need protection against contact with liquid and inhalation of vapor (see sect. 8).

Waste management / Disposal: Absorb small spills with paper towel or vermiculite. Contain large spills and collect if feasible, or absorb with vermiculite or sand. Place waste solvent or absorbent into closed containers for disposal using nonsparking tools. Liquid can be flushed with water to an open holding area for handling. Do not flush to sewer, watershed, or waterway.

Place in suitable container for disposal by a licensed contractor or burn in an approved incinerator. Consider reclaiming by distillation. Contaminated absorbent can be buried in a sanitary landfill. Follow all Federal, state, and local regulations. TLm 96: 100-10 ppm. Toluene is designated as a hazardous waste by the EPA. The EPA (RCRA) HW No. is U220 (40 CFR 261). The reportable quantity (RQ) is 1000 lbs/454 kg (40 CFR 117).

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:

Goggles: Safety glasses or splash goggles should be worn in all work areas.

Gloves: Neoprene gloves should be worn.

Respirator: For emergency or nonroutine exposures where the TLV may be exceeded, use an organic chemical cartridge respirator if concentration is less than 200 ppm and an approved canister gas mask or self-contained breathing apparatus with full facepiece if concentration is greater than 200 ppm.

 SPECIAL PROTECTION INFORMATION continues on page 5

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MSDS No: Genium / 317
Revision: D
Date: April, 1986

SPECIAL PROTECTION INFORMATION continued from page 4

Other: Apron, face shield, boots, and other appropriate protective clothing and equipment should be available and worn as necessary to prevent skin and eye contact.

Remove contaminated clothing immediately and do not wear it until it has been properly laundered.

Workplace considerations:

Ventilation: Provide general and local exhaust ventilation to meet TLV requirements. Ventilation fans and other electrical service must be nonsparking and have an explosion-proof design. Exhaust hoods should have a face velocity of at least 100 lfm (linear feet per minute) and be designed to capture heavy vapor.

Safety stations:
Eyewash stations and safety showers should be readily available in use and handling areas.

Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.

SECTION IX. SPECIAL PRECAUTIONS

Storage segregation: Store in a cool, dry, well-ventilated area away from oxidizing agents, heat, sparks, or open flame. Storage areas must meet OSHA requirements for class IB flammable liquids. Use metal safety cans for handling small amounts. Protect containers from physical damage. Use only with adequate ventilation. Avoid contact with eyes, skin, or clothing. Do not inhale or ingest. Use caution when handling this compound because it can be absorbed through intact skin in toxic amounts.

Special handling / storage: Ground and bond metal containers and equipment to prevent static sparks when making transfers. Do not smoke in use or storage areas. Use nonsparking tools.

Engineering controls: Preplacement and periodic medical exams emphasizing the liver, kidneys, nervous system, lungs, heart, and blood should be provided. Workers exposed to concentrations greater than the action level (50 ppm) should be examined at least once a year. Use of alcohol can aggravate the toxic effects of toluene.

Emptied containers contain product residues. Handle accordingly! Toluene is designated as a hazardous substance by the EPA (40 CFR 116).

DOT Class: Flammable Liquid UN Register: UN1294
Data source code(s): 1-9, 12, 16, 20, 21, 24, 26, 34, 81, 82. CR

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SPECIAL PRECAUTIONS continued from page 5

April, 1986

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Tritium (^3H)

Half-Life:

Physical: 12.3 years.

Biological: ~10 days (range: 4–18) total body for HTO.

Special Chemical and Biological Characcteristics: Not selectively concentrated in any organ. Metabolized as H_2O. Tritium is assumed to be readily and completely absorbed by the body and to be distributed evenly throughout the body.

Principal Human Metabolic and Dosimetric Parameters:

$f_1 = 1.0$.

ALI (μCi) = 8.1×10^4 (HTO).

DAC (μCi/cm^3)= 2.2×10^7 (HTO).

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Product: XYLENE (MIXED ISOMERS)

MSDS No: Genium / 318
Revision: C
Date: November, 1980

SECTION I. MATERIAL IDENTIFICATION

Trade/Material Name: XYLENE (MIXED ISOMERS)

Other Designations: Xylol, Dimethylbenzene, $C_6H_4(CH_3)_2$; ASTM D843, D845 AND D846; GE Material D5B9

CAS: 001 330 207

Available from many suppliers, including: EXXON Company USA and Shell Chemical Company.

SECTION II. INGREDIENTS AND HAZARDS

Ingredient Name:	Percent:	Exposure Limits:
Xylene (o, m, p-isomers)	>90	8-hr TWA 100 ppm (skin)** or 435 mg/m³ Xylene Typical
C_7 to C_9 Hydrocarbons*	<10	Human: Inhalation TCLo 200 ppm (Irritation Effects) Rat: Oral LD_{50} 4.3 g/kg Human: Oral LDLo 50 mg/kg

*Material may contain ethylbenzene (8-hr TWA 100 ppm) & traces of toluene, and C_9 aromatic & aliphatic hydrocarbons. Some commercial products may contain over 10% non-xylene hydrocarbons, mostly ethylbenzene.
** Current OSHA standard and ACGIH (1980) TLV. NIOSH has proposed a 10-hr TWA of 100 ppm with a 200 ppm ceiling level (10 min. sample).
STATUS: NCI bioassay for carcinogenesis study 9/78. TLV set to prevent irritant effects and CNS depression.

SECTION III. PHYSICAL DATA

Appearance & Odor: Light colored or colorless, mobile liquid with an aromatic odor. The recognition threshold (100% of test panel) is about 0.3 ppm in air (unfatigued) for xylene.

Boiling point: 135-145°C*, 1 atm
Vapor pressure: ca 6 @ 20°C, mm Hg
Water solubility (%): Negligible
Vapor density (air=1): 3.7
Evaporation rate: 0.6 (BuAc=1)
Specific gravity (H_2O=1): 0.86-0.87
% volatile by volume: ca 100
Molecular weight: 106.18

 PHYSICAL DATA continues on page 2

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MSDS No: Genium / 318
Revision: C
Date: November, 1980

PHYSICAL DATA continued from page 1

* Wider and narrower boiling range materials are commercially available.

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point (method): >77°F (TCC) **Limits: LEL %:** 1 **UEL %:** 7

Extinguishing Media: Use dry chemical, foam, CO_2, and water fog or steam to provide a smothering effect on fire. A water stream can scatter flames. A spray of water may be used to cool fire-exposed containers.

Autoignition Temp: 867°F

Unusual fire or explosion hazards: This flammable liquid is a dangerous fire hazard and a moderate explosion hazard when exposed to heat or flames. Heavier-than-air vapors can flow along surfaces to distant ignition sources and flash back.

Special fire-fighting procedures: Firefighters should use self-contained breathing apparatus.

SECTION V. REACTIVITY DATA

Material is stable in closed containers at room temperature. Hazardous polymerization cannot occur

Conditions to avoid: It is flammable (OSHA Class IC liquid) and can form explosive mixtures with air. Keep away from sources of heat, sources of ignition and strong oxidizing agents.

Thermal-oxidative degradation in air can produce toxic vapors and gases, including carbon monoxide and oxides of nitrogen.

SECTION VI. HEALTH HAZARD INFORMATION

Summary of risks: Inhalation of xylene at the TLV may cause mild irritation and dizziness in sensitive persons. Concentrations from 100-200 ppm may cause nausea, headache and depression. Vapor levels >200 ppm can have an anesthesic effect. Skin contact may produce mild irritation and skin defatting. Eye contact may cause burning and irritation. Ingestion of xylene may cause poisoning. One ounce or more may be fatal. Aspiration can be a hazard if this material is swallowed.

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HEALTH HAZARD INFORMATION continued from page 2

First aid:

Eye contact: Irrigate with water for 15 minutes. Get medical attention!

Skin contact: Wash with soap and water. Remove contaminated clothing promptly. Replace lost skin oils with approved lotions or creams.

Inhalation: Remove victim to fresh air. Restore breathing if required. Get medical attention if symptoms persist or if nausea or collapse has occurred.

Ingestion: Get medical attention immediately! Give white mineral oil demulcent and saline cathartic, but do not induce vomiting unless directed by a physician.

Maintain observation of patient for possible delayed onset of pulmonary edema.

SECTION VII. SPILL, LEAK AND DISPOSAL PROCEDURES

Spill / Leak procedures: Notify safety personnel. Remove all ignition sources. Provide adequate ventilation. Use vermiculite or sand to absorb spill; scrape up with nonsparking tools and place in a covered metal container. The absorbed material may be burned in an open pit, or placed in cardboard boxes and burned in an incinerator. Spilled liquid can be flushed away from sensitive locations with a water stream; flush to open area not to sewer!

Waste management / Disposal: Scrap liquid may be atomized into an approved incinerator, or it may be disposed of via a licensed solvent disposal company. When large amounts are involved reclaimation procedures may prove economical. Follow Federal, State, and Local regulations.

AQUATIC TOXICITY rating TLm 96: 100-10 ppm.

SECTION VIII. SPECIAL PROTECTION INFORMATION

Personal protective equipment:

Goggles: Safety glasses or goggles should be used for eye protection.

Gloves: Buna-N rubber gloves should be worn to prevent contact of xylene with the skin.

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Revision: C
Date: November, 1980

SPECIAL PROTECTION INFORMATION continued from page 3

Respirator: Use approved organic vapor canister respirators for short periods of nonroutine work or emergency situations at up to 1000-2000 ppm and approved self-contained respirators for higher and unknown vapor levels. Full facepiece required.

Other: Aprons should be used.

Workplace considerations:

Ventilation: Provide general ventilation and efficient exhaust ventilation (explosion-proof equipment) to meet TLV requirements and to control heavier-than-air vapors. Use >100 1 lfm face velocity for exhaust hoods.

Comprehensive preplacement and biennial medical examinations to be directed toward, but not limited to, liver, kidney, gastrointestinal disorders, skin irritation, and the central nervous system.
Eyewash stations should be readily available to use areas.

SECTION IX. SPECIAL PRECAUTIONS

Storage segregation: Store in closed containers in a clean, cool, well-ventilated area, away from sources of heat, sources of ignition and strong oxidizing agents. Protect containers from physical damage. Bond and ground metal containers when transferring liquid. Use metal safety cans for small amounts. Use nonsparking tools for work in solvent area. No Smoking in areas of use or storage.

Other precautions: Prevent skin contact and remove contaminated clothing promptly. Avoid repeated or prolonged breathing of vapor. Do not ingest!

Data source code(s): 1-12, 19-21, 23, 26, 31, 34, 37-39. N

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Appendix D
Trench and Excavation Safety

(2) Decks and other working surfaces shall be maintained in a safe condition.

(3) Employees shall not be permitted to pass fore and aft, over, or around deckloads, unless there is a safe passage.

(4) Employees shall not be permitted to walk over deckloads from rail to coaming unless there is a safe passage. If it is necessary to stand at the outboard or inboard edge of the deckload where less than 24 inches of bulwark, rail, coaming, or other protection exists, all employees shall be provided with a suitable means of protection against falling from the deckload.

(d) *First-aid and lifesaving equipment.* (1) Provisions for rendering first aid and medical assistance shall be in accordance with Subpart D of this part.

(2) The employer shall ensure that there is in the vicinity of each barge in use at least one U.S. Coast Guard-approved 30-inch lifering with not less than 90 feet of line attached, and at least one portable or permanent ladder which will reach the top of the apron to the surface of the water. If the above equipment is not available at the pier, the employer shall furnish it during the time that he is working the barge.

(3) Employees walking or working on the unguarded decks of barges shall be protected with U.S. Coast Guard-approved work vests or buoyant vests.

(e) *Commercial diving operations.* Commercial diving operations shall be subject to Subpart T of Part 1910, §§ 1910.401-1910.441, of this chapter.

[39 FR 22801, June 24, 1974, as amended at 42 FR 37674, July 22, 1977]

§ 1926.606 Definitions applicable to this subpart.

(a) "Apron"—The area along the waterfront edge of the pier or wharf.

(b) "Bulwark"—The side of a ship above the upper deck.

(c) "Coaming"—The raised frame, as around a hatchway in the deck, to keep out water.

(d) "Jacob's ladder"—A marine ladder of rope or chain with wooden or metal rungs.

(e) "Rail", for the purpose of § 1926.605, means a light structure serving as a guard at the outer edge of a ship's deck.

Subpart P—Excavations, Trenching, and Shoring

§ 1926.650 General protection requirements.

(a) Walkways, runways, and sidewalks shall be kept clear of excavated material or other obstructions and no sidewalks shall be undermined unless shored to carry a minimum live load of one hundred and twenty-five (125) pounds per square foot.

(b) If planks are used for raised walkways, runways, or sidewalks, they shall be laid parallel to the length of the walk and fastened together against displacement.

(c) Planks shall be uniform in thickness and all exposed ends shall be provided with beveled cleats to prevent tripping.

(d) Raised walkways, runways, and sidewalks shall be provided with plank steps on strong stringers. Ramps, used in lieu of steps, shall be provided with cleats to insure a safe walking surface.

(e) All employees shall be protected with personal protective equipment for the protection of the head, eyes, respiratory organs, hands, feet, and other parts of the body as set forth in Subpart E of this part.

(f) Employees exposed to vehicular traffic shall be provided with and shall be instructed to wear warning vests marked with or made of reflectorized or high visibility material.

(g) Employees subjected to hazardous dusts, gases, fumes, mists, or atmospheres deficient in oxygen, shall be protected with approved respiratory protection as set forth in Subpart D of this part.

(h) No person shall be permitted under loads handled by power shovels, derricks, or hoists. To avoid any spillage employees shall be required to stand away from any vehicle being loaded.

(i) Daily inspections of excavations shall be made by a competent person. If evidence of possible cave-ins or slides is apparent, all work in the excavation shall cease until the necessary

precautions have been taken to safeguard the employees.

§ 1926.651 Specific excavation requirements.

(a) Prior to opening an excavation, effort shall be made to determine whether underground installations; i.e., sewer, telephone, water, fuel, electric lines, etc., will be encountered, and if so, where such underground installations are located. When the excavation approaches the estimated location of such an installation, the exact location shall be determined and when it is uncovered, proper supports shall be provided for the existing installation. Utility companies shall be contacted and advised of proposed work prior to the start of actual excavation.

(b) Trees, boulders, and other surface encumbrances, located so as to create a hazard to employees involved in excavation work or in the vicinity thereof at any time during operations, shall be removed or made safe before excavating is begun.

(c) The walls and faces of all excavations in which employees are exposed to danger from moving ground shall be guarded by a shoring system, sloping of the ground, or some other equivalent means.

(d) Excavations shall be inspected by a competent person after every rainstorm or other hazard-increasing occurrence, and the protection against slides and cave-ins shall be increased if necessary.

(e) The determination of the angle of repose and design of the supporting system shall be based on careful evaluation of pertinent factors such as: Depth of cut; possible variation in water content of the material while the excavation is open; anticipated changes in materials from exposure to air, sun, water, or freezing; loading imposed by structures, equipment, overlying material, or stored material; and vibration from equipment, blasting, traffic, or other sources.

(f) Supporting systems; i.e., piling, cribbing, shoring, etc., shall be designed by a qualified person and meet accepted engineering requirements. When tie rods are used to restrain the top of sheeting or other retaining systems, the rods shall be securely anchored well back of the angle of repose. When tight sheeting or sheet piling is used, full loading due to ground water table shall be assumed, unless prevented by weep holes or drains or other means. Additional stringers, ties, and bracing shall be provided to allow for any necessary temporary removal of individual supports.

(g) All slopes shall be excavated to at least the angle of repose except for areas where solid rock allows for line drilling or presplitting.

(h) The angle of repose shall be flattened when an excavation has water conditions, silty materials, loose boulders, and areas where erosion, deep frost action, and slide planes appear.

(i)(1) In excavations which employees may be required to enter, excavated or other material shall be effectively stored and retained at least 2 feet or more from the edge of the excavation.

(2) As an alternative to the clearance prescribed in paragraph (i)(1) of this section, the employer may use effective barriers or other effective retaining devices in lieu thereof in order to prevent excavated or other materials from falling into the excavation.

(j) Sides, slopes, and faces of all excavations shall meet accepted engineering requirements by scaling, benching, barricading, rock bolting, wire meshing, or other equally effective means. Special attention shall be given to slopes which may be adversely affected by weather or moisture content.

(k) Support systems shall be planned and designed by a qualified person when excavation is in excess of 20 feet in depth, adjacent to structures or improvements, or subject to vibration or ground water.

(l) Materials used for sheeting, sheet piling, cribbing, bracing, shoring, and underpinning shall be in good serviceable condition, and timbers shall be sound, free from large or loose knots, and of proper dimensions.

(m) Special precations shall be taken in sloping or shoring the sides of excavations adjacent to a previously backfilled excavation or a fill, particularly when the separation is less than the depth of the excavation. Particular attention also shall be paid to joints and

seams of material comprising a face and the slope of such seams and joints.

(n) Except in hard rock, excavations below the level of the base of footing of any foundation or retaining wall shall not be permitted, unless the wall is underpinned and all other precautions taken to insure the stability of the adjacent walls for the protection of employees involved in excavation work or in the vicinity thereof.

(o) If the stability of adjoining buildings or walls is endangered by excavations, shoring, bracing, or underpinning shall be provided as necessary to insure their safety. Such shoring, bracing, or underpinning shall be inspected daily or more often, as conditions warrant, by a competent person and the protection effectively maintained.

(p) Diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering an excavation and to provide adequate drainage of the area adjacent to the excavation. Water shall not be allowed to accumulate in an excavation.

(q) If it is necessary to place or operate power shovels, derricks, trucks, materials, or other heavy objects on a level above and near an excavation, the side of the excavation shall be sheet-piled, shored, and braced as necessary to resist the extra pressure due to such superimposed loads.

(r) Blasting and the use of explosives shall be performed in accordance with Subpart U of this part.

(s) When mobile equipment is utilized or allowed adjacent to excavations, substantial stop logs or barricades shall be installed. If possible, the grade should be away from the excavation.

(t) Adequate barrier physical protection shall be provided at all remotely located excavations. All wells, pits, shafts, etc., shall be barricaded or covered. Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., shall be backfilled.

(u) If possible, dust conditions shall be kept to a minimum by the use of water, salt, calcium chloride, oil, or other means.

(v) In locations where oxygen deficiency or gaseous conditions are possible, air in the excavation shall be tested. Controls, as set forth in Subparts D and E of this part, shall be established to assure acceptable atmospheric conditions. When flammable gases are present, adequate ventilation shall be provided or sources of ignition shall be eliminated. Attended emergency rescue equipment, such as breathing apparatus, a safety harness and line, basket stretcher, etc., shall be readily available where adverse atmospheric conditions may exist or develop in an excavation.

(w) Where employees or equipment are required or permitted to cross over excavations, walkways or bridges with standard guardrails shall be provided.

(x) Where ramps are used for employees or equipment, they shall be designed and constructed by qualified persons in accordance with accepted engineering requirements.

(y) All ladders used on excavation operations shall be in accordance with the requirements of Subpart L of this part.

§ 1926.652 Specific trenching requirements.

(a) Banks more than 5 feet high shall be shored, laid back to a stable slope, or some other equivalent means of protection shall be provided where employees may be exposed to moving ground or cave-ins. Refer to Table P-1 as a guide in sloping of banks. Trenches less than 5 feet in depth shall also be effectively protected when examination of the ground indicates hazardous ground movement may be expected.

(b) Sides of trenches in unstable or soft material, 5 feet or more in depth, shall be shored, sheeted, braced, sloped, or otherwise supported by means of sufficient strength to protect the employees working within them. See Tables P-1, P-2 (following paragraph (g) of this section).

(c) Sides of trenches in hard or compact soil, including embankments, shall be shored or otherwise supported when the trench is more than 5 feet in depth and 8 feet or more in length. In lieu of shoring, the sides of the trench

above the 5-foot level may be sloped to preclude collapse, but shall not be steeper than a 1-foot rise to each ½-foot horizontal. When the outside diameter of a pipe is greater than 6 feet, a bench of 4-foot minimum shall be provided at the toe of the sloped portion.

(d) Materials used for sheeting and sheet piling, bracing, shoring, and underpinning, shall be in good serviceable condition, and timbers used shall be sound and free from large or loose knots, and shall be designed and installed so as to be effective to the bottom of the excavation.

(e) Additional precautions by way of shoring and bracing shall be taken to prevent slides or cave-ins when excavations or trenches are made in locations adjacent to backfilled excavations, or where excavations are subjected to vibrations from railroad or highway traffic, the operation of machinery, or any other source.

(f) Employees entering bell-bottom pier holes shall be protected by the installation of a removable-type casing of sufficient strength to resist shifting of the surrounding earth. Such temporary protection shall be provided for the full depth of that part of each pier hole which is above the bell. A lifeline, suitable for instant rescue and securely fastened to a shoulder harness, shall be worn by each employee entering the shafts. This lifeline shall be individually manned and separate from any line used to remove materials excavated from the bell footing.

(g)(1) Minimum requirements for trench timbering shall be in accordance with Table P-2.

(2) Braces and diagonal shores in a wood shoring system shall not be subjected to compressive stress in excess of values given by the following formula:

$$S = 13 - 20L/D$$

Maximum ratio $L/D = 50$

Where:

L = Length, unsupported, in inches.

D = Least side of the timber in inches.

S = Allowable stress in pounds per square inch of cross-section.

Table P - 1

APPROXIMATE ANGLE OF REPOSE
FOR SLOPING OF SIDES OF EXCAVATIONS

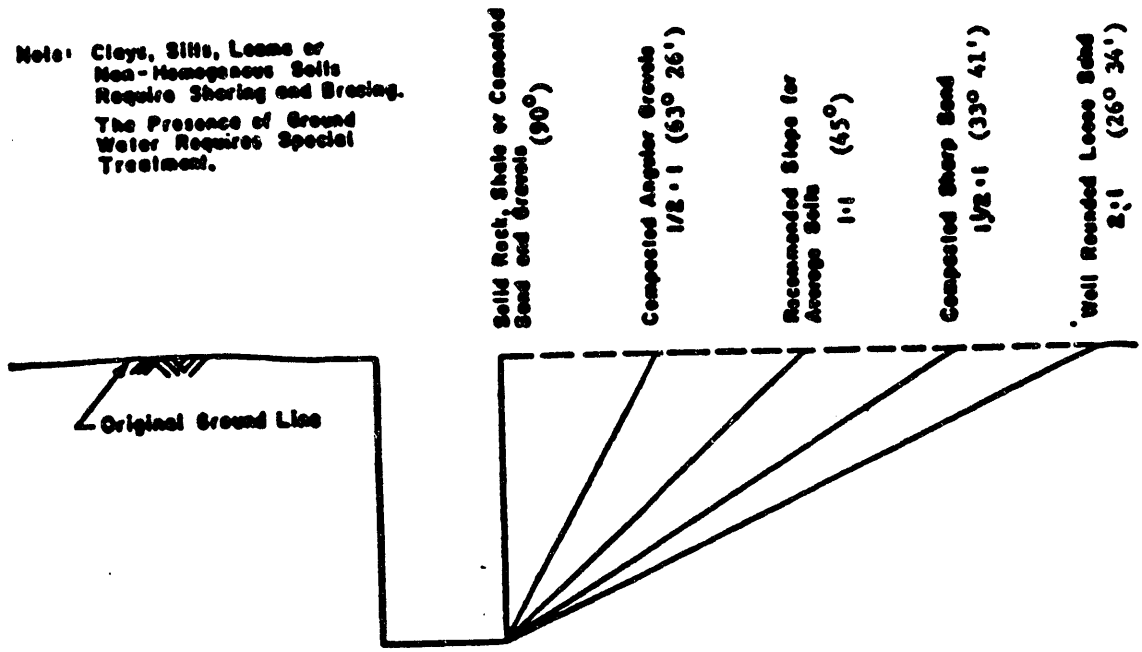

TABLE P-2—TRENCH SHORING—MINIMUM REQUIREMENTS

Depth of trench	Kind or condition of earth	Size and spacing of members										
		Uprights		Stringers		Cross braces [1]; Width of trench				Maximum spacing		
		Minimum dimension	Maximum spacing	Minimum dimension	Maximum spacing	Up to 3 feet	3 to 6 feet	6 to 9 feet	9 to 12 feet	12 to 15 feet	Vertical	Horizontal
Feet		Inches	Feet	Inches	Feet	Inches	Inches	Inches	Inches	Inches	Feet	Feet
5 to 10	Hard, compact	3×4 or 2×6	6	.....	.....	2×6	4×4	4×6	6×6	6×8	4	6
	Likely to crack	3×4 or 2×6	3	4×6	4	2×6	4×4	4×6	6×6	6×8	4	6
	Soft, sandy, or filled	3×4 or 2×6	Close sheeting	4×6	4	4×4	4×6	6×6	6×8	8×8	4	6
	Hydrostatic pressure	3×4 or 2×6	Close sheeting	6×8	4	4×4	4×6	6×6	6×8	8×8	4	6
10 to 15	Hard	3×4 or 2×6	4	4×6	4	4×4	4×6	6×6	6×8	8×8	4	6
	Likely to crack	3×4 or 2×6	2	4×6	4	4×4	4×6	6×6	6×8	8×8	.....	6
	Soft, sandy, or filled	3×4 or 2×6	Close sheeting	4×6	4	4×6	6×6	6×8	8×8	8×10	4	6
	Hydrostatic pressure	3×6	Close sheeting	8×10	4	4×6	6×6	6×8	8×8	8×10	4	6
15 to 20	All kinds or conditions	3×6	Close sheeting	4×12	4	4×12	6×6	6×8	8×10	10×10	4	6
Over 20	All kinds or conditions	3×6	Close sheeting	6×8	4	4×12	8×8	8×10	10×10	10×12	4	6

[1] Trench jacks may be used in lieu of, or in combination with, cross braces.
Shoring is not required in solid rock, hard shale, or hard slag.
Where desirable, steel sheet piling and bracing of equal strength may be substituted for wood.

(h) When employees are required to be in trenches 4 feet deep or more, an adequate means of exit, such as a ladder or steps, shall be provided and located so as to require no more than 25 feet of lateral travel.

(i) Bracing or shoring of trenches shall be carried along with the excavation.

(j) Cross braces or trench jacks shall be placed in true horizontal position, be spaced vertically, and be secured to prevent sliding, falling, or kickouts.

(k) Portable trench boxes or sliding trench shields may be used for the protection of personnel in lieu of a shoring system or sloping. Where such trench boxes or shields are used, they shall be designed, constructed, and maintained in a manner which will provide protection equal to or greater than the sheeting or shoring required for the trench.

(l) Backfilling and removal of trench supports shall progress together from the bottom of the trench. Jacks or braces shall be released slowly and, in unstable soil, ropes shall be used to pull out the jacks or braces from above after employees have cleared the trench.

§ 1926.653 Definitions applicable to this subpart.

(a) "Accepted engineering requirements (or practices)"—Those requirements or practices which are compatible with standards required by a registered architect, a registered professional engineer, or other duly licensed or recognized authority.

(b) "Angle of repose"—The greatest angle above the horizontal plane at which a material will lie without sliding.

(c) "Bank"—A mass of soil rising above a digging level.

(d) "Belled excavation"—A part of a shaft or footing excavation, usually near the bottom and bell-shaped; i.e., an enlargement of the cross section above.

(e) "Braces (trench)"—The horizontal members of the shoring system whose ends bear against the uprights or stringers.

(f) "Excavation"—Any manmade cavity or depression in the earth's surface, including its sides, walls, or faces, formed by earth removal and producing unsupported earth conditions by reasons of the excavation. If installed forms or similar structures reduce the depth-to-width relationship, an excavation may become a trench.

(g) "Faces"—See paragraph (k) of this section.

(h) "Hard compact soil"—All earth materials not classified as running or unstable.

(i) "Kickouts"—Accidental release or failure of a shore or brace.

(j) "Sheet pile"—A pile, or sheeting, that may form one of a continuous interlocking line, or a row of timber, concrete, or steel piles, driven in close contact to provide a tight wall to resist the lateral pressure of water, adjacent earth, or other materials.

(k) "Sides", "Walls", or "Faces"—The vertical or inclined earth surfaces formed as a result of excavation work.

(l) "Slope"—The angle with the horizontal at which a particular earth material will stand indefinitely without movement.

(m) "Stringers" (wales)—The horizontal members of a shoring system whose sides bear against the uprights or earth.

(n) "Trench"—A narrow excavation made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench is not greater than 15 feet.

(o) "Trench jack"—Screw or hydraulic type jacks used as cross bracing in a trench shoring system.

(p) "Trench shield"—A shoring system composed of steel plates and bracing, welded or bolted together, which support the walls of a trench from the ground level to the trench bottom and which can be moved along as work progresses.

(q) "Unstable soil"—Earth material, other than running, that because of its nature or the influence of related conditions, cannot be depended upon to remain in place without extra support, such as would be furnished by a system of shoring.

(r) "Uprights"—The vertical members of a shoring system.

(s) "Wales"—See paragraph (m) of this section.

(t) "Walls"—See paragraph (k) of this section.

Appendix E
Electrical Safety

from the area to be heated to prevent ignition.

(c) Protection against toxic preservative coatings: (1) In enclosed spaces, all surfaces covered with toxic preservatives shall be stripped of all toxic coatings for a distance of at least 4 inches from the area of heat application, or the employees shall be protected by air line respirators, meeting the requirements of Subpart E of this part.

(2) In the open air, employees shall be protected by a respirator, in accordance with requirements of Subpart E of this part.

(d) The preservative coatings shall be removed a sufficient distance from the area to be heated to ensure that the temperature of the unstripped metal will not be appreciably raised. Artificial cooling of the metal surrounding the heating area may be used to limit the size of the area required to be cleaned.

Subpart K—Electrical

General

§ 1926.400 Introduction.

This subpart addresses electrical safety requirements that are necessary for the practical safeguarding of employees involved in construction work and is divided into four major divisions and applicable definitions as follows:

(a) *Installation safety requirements.* Installation safety requirements are contained in §§ 1926.402 through 1926.408. Included in this category are electrical equipment and installations used to provide electric power and light on jobsites.

(b) *Safety-related work practices.* Safety-related work practices are contained in §§ 1926.416 and 1926.417. In addition to covering the hazards arising from the use of electricity at jobsites, these regulations also cover the hazards arising from the accidental contact, direct or indirect, by employees with all energized lines, above or below ground, passing through or near the jobsite.

(c) *Safety-related maintenance and environmental considerations.* Safety-related maintenance and environmental considerations are contained in §§ 1926.431 and 1926.432.

(d) *Safety requirements for special equipment.* Safety requirements for special equipment are contained in § 1926.441.

(e) *Definitions.* Definitions applicable to this Subpart are contained in § 1926.449.

§ 1926.401 [Reserved.]

Installation Safety Requirements

§ 1926.402 Applicability.

(a) *Covered.* Sections 1926.402 through 1926.408 contain installation safety requirements for electrical equipment and installations used to provide electric power and light at the jobsite. These sections apply to installations, both temporary and permanent, used on the jobsite; but these sections do not apply to existing permanent installations that were in place before the construction activity commenced.

NOTE: If the electrical installation is made in accordance with the National Electrical Code ANSI/NFPA 70-1984, exclusive of Formal Interpretations and Tentative Interim Amendments, it will be deemed to be in compliance with §§ 1926.403 through 1926.408, except for §§ 1926.404(b)(1) and 1926.405(a)(2)(ii)(E), (F), (G), and (J).

(b) *Not covered.* Sections 1926.402 through 1926.408 do not cover installations used for the generation, transmission, and distribution of electric energy, including related communication, metering, control, and transformation installations. (However, these regulations do cover portable and vehicle-mounted generators used to provide power for equipment used at the jobsite.) See Subpart V of this Part for the construction of power distribution and transmission lines.

§ 1926.403 General requirements.

(a) *Approval.* All electrical conductors and equipment shall be approved.

(b) *Examination, installation, and use of equipment*—(1) *Examination.* The employer shall ensure that electrical equipment is free from recognized hazards that are likely to cause death or serious physical harm to employees. Safety of equipment shall be determined on the basis of the following considerations:

(i) Suitability for installation and use in conformity with the provisions of this subpart. Suitability of equipment for an identified purpose may be evidenced by listing, labeling, or certification for that identified purpose.

(ii) Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.

(iii) Electrical insulation.

(iv) Heating effects under conditions of use.

(v) Arcing effects.

(vi) Classification by type, size, voltage, current capacity, specific use.

(vii) Other factors which contribute to the practical safeguarding of employees using or likely to come in contact with the equipment.

(2) *Installation and use.* Listed, labeled, or certified equipment shall be installed and used in accordance with instructions included in the listing, labeling, or certification.

(c) *Interrupting rating.* Equipment intended to break current shall have an interrupting rating at system voltage sufficient for the current that must be interrupted.

(d) *Mounting and cooling of equipment.*—(1) *Mounting.* Electric equipment shall be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used.

(2) *Cooling.* Electrical equipment which depends upon the natural circulation of air and convection principles for cooling of exposed surfaces shall be installed so that room air flow over such surfaces is not prevented by walls or by adjacent installed equipment. For equipment designed for floor mounting, clearance between top surfaces and adjacent surfaces shall be provided to dissipate rising warm air. Electrical equipment provided with ventilating openings shall be installed so that walls or other obstructions do not prevent the free circulation of air through the equipment.

(e) *Splices.* Conductors shall be spliced or joined with splicing devices designed for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device designed for the purpose.

(f) *Arcing parts.* Parts of electric equipment which in ordinary operation produce arcs, sparks, flames, or molten metal shall be enclosed or separated and isolated from all combustible material.

(g) *Marking.* Electrical equipment shall not be used unless the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified is placed on the equipment and unless other markings are provided giving voltage, current, wattage, or other ratings as necessary. The marking shall be of sufficient durability to withstand the environment involved.

(h) *Identification of disconnecting means and circuits.* Each disconnecting means required by this subpart for motors and appliances shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. Each service, feeder, and branch circuit, at its disconnecting means or overcurrent device, shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. These markings shall be of sufficient durability to withstand the environment involved.

(i) *600 Volts, nominal, or less.* This paragraph applies to equipment operating at 600 volts, nominal, or less.

(l) *Working space about electric equipment.* Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.

(i) *Working clearances.* Except as required or permitted elsewhere in this subpart, the dimension of the working space in the direction of access to live parts operating at 600 volts or less and likely to require examination, adjustment, servicing, or maintenance while alive shall not be less than indicated in Table K-1. In addition to the dimension shown in Table K-1, workspace shall not be less than 30 inches (762

mm) wide in front of the electric equipment. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. Walls constructed of concrete, brick, or tile are considered to be grounded. Working space is not required in back of assemblies such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

TABLE K-1—WORKING CLEARANCES

Nominal voltage to ground	Minimum clear distance for conditions[1]		
	(a)	(b)	(c)
	Feet[2]	Feet[2]	Feet[2]
0–150	3	3	3
151–600	3	3 1/2	4

[1]Conditions (a), (b), and (c) are as follows: (a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating material. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts. (b) Exposed live parts on one side and grounded parts on the other side. (c) Exposed live parts on both sides of the workspace [not guarded as provided in Condition (a)] with the operator between.

[2]For International System of Units (SI): one foot = 0.3048m.

(ii) *Clear spaces.* Working space required by this subpart shall not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be guarded.

(iii) *Access and entrance to working space.* At least one entrance shall be provided to give access to the working space about electric equipment.

(iv) *Front working space.* Where there are live parts normally exposed on the front of switchboards or motor control centers, the working space in front of such equipment shall not be less than 3 feet (914 mm).

(v) *Headroom.* The minimum headroom of working spaces about service equipment, switchboards, panelboards, or motor control centers shall be 6 feet 3 inches (1.91 m).

(2) *Guarding of live parts.*—(i) Except as required or permitted elsewhere in this subpart, live parts of electrical equipment operating at 50 volts or more shall be guarded against accidental contact by cabinets or other forms of enclosures, or by any of the following means:

(A) By location in a room, vault, or similar enclosure that is accessible only to qualified persons.

(B) By partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.

(C) By location on a balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons.

(D) By elevation of 8 feet (2.44 m) or more above the floor or other working surface and so installed as to exclude unqualified persons.

(ii) In locations where electric equipment would be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

(iii) Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

(j) *Over 600 volts, nominal.*—(1) *General.* Conductors and equipment used on circuits exceeding 600 volts, nominal, shall comply with all applicable provisions of paragraphs (a) through (g) of this section and with the following provisions which supplement or modify those requirements. The provisions of paragraphs (j)(2), (j)(3), and (j)(4) of this section do not apply to equipment on the supply side of the service conductors.

(2) *Enclosure for electrical installations.* Electrical installations in a vault, room, closet or in an area surrounded by a wall, screen, or fence, access to which is controlled by lock and key or other equivalent means, are considered to be accessible to qualified persons only. A wall, screen, or fence less than 8 feet (2.44 m) in height is not considered adequate to prevent access unless it has other features that provide a degree of isolation equivalent to an 8-foot (2.44-m) fence. The entrances to all buildings,

rooms or enclosures containing exposed live parts or exposed conductors operating at over 600 volts, nominal, shall be kept locked or shall be under the observation of a qualified person at all times.

(i) *Installations accessible to qualified persons only.* Electrical installations having exposed live parts shall be accessible to qualified persons only and shall comply with the applicable provisions of paragraph (j)(3) of this section.

(ii) *Installations accessible to unqualified persons.* Electrical installations that are open to unqualified persons shall be made with metal-enclosed equipment or shall be enclosed in a vault or in an area, access to which is controlled by a lock. Metal-enclosed switchgear, unit substations, transformers, pull boxes, connection boxes, and other similar associated equipment shall be marked with appropriate caution signs. If equipment is exposed to physical damage from vehicular traffic, guards shall be provided to prevent such damage. Ventilating or similar openings in metal-enclosed equipment shall be designed so that foreign objects inserted through these openings will be deflected from energized parts.

(3) *Workspace about equipment.* Sufficient space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment. Where energized parts are exposed, the minimum clear workspace shall not be less than 6 feet 6 inches (1.98 m) high (measured vertically from the floor or platform), or less than 3 feet (914 mm) wide (measured parallel to the equipment). The depth shall be as required in Table K-2. The workspace shall be adequate to permit at least a 90-degree opening of doors or hinged panels.

(i) *Working space.* The minimum clear working space in front of electric equipment such as switchboards, control panels, switches, circuit breakers, motor controllers, relays, and similar equipment shall not be less than specified in Table K-2 unless otherwise specified in this subpart. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. However, working space is not required in back of equipment such as deadfront switchboards or control assemblies where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on de-energized parts on the back of enclosed equipment, a minimum working space of 30 inches (762 mm) horizontally shall be provided.

TABLE K-2—MINIMUM DEPTH OF CLEAR WORKING SPACE IN FRONT OF ELECTRIC EQUIPMENT

Nominal voltage to ground	Conditions[1]		
	(a)	(b)	(c)
	Feet[2]	Feet[2]	Feet[2]
601 to 2,500	3	4	5
2,501 to 9,000	4	5	6
9,001 to 25,000	5	6	9
25,001 to 75 kV	6	8	10
Above 75kV	8	10	12

[1]Conditions (a), (b), and (c) are as follows: (a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating materials. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts. (b) Exposed live parts on one side and grounded parts on the other side. Walls constructed of concrete, brick, or tile are considered to be grounded surfaces. (c) Exposed live parts on both sides of the workspace [not guarded as provided in Condition (a)] with the operator between.

[2]For SI units: one foot = 0.3048m.

(ii) *Lighting outlets and points of control.* The lighting outlets shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment. The points of control shall be so located that persons are not likely to come in contact with any live part or moving part of the equipment while turning on the lights.

(iii) *Elevation of unguarded live parts.* Unguarded live parts above working space shall be maintained at elevations not less than specified in Table K-3.

TABLE K-3 ELEVATION OF UNGUARDED ENERGIZED PARTS ABOVE WORKING SPACE

Nominal voltage Between phases	Minimum elevation
601-7,500	8 feet 6 inches[1]
7,501-35,000	9 feet
Over 35kV	9 feet + 0.37 inches per kV above 35kV

[1]For SI units: one inch = 25.4 mm; one foot = 0.3048 m

(4) *Entrance and access to workspace.* At least one entrance not less than 24 inches (610 mm) wide and 6 feet 6 inches (1.98 m) high shall be provided to give access to the working space about electric equipment. On switchboard and control panels exceeding 48 inches (1.22 m) in width, there shall be one entrance at each end of such board where practicable. Where bare energized parts at any voltage or insulated energized parts above 600 volts are located adjacent to such entrance, they shall be guarded. (Information collection requirements contained in paragraphs (g) and (h) were approved by the Office of Management and Budget under control number: 1218-0130.)

§ 1926.404 Wiring design and protection.

(a) *Use and identification of grounded and grounding conductors.*—

(1) *Identification of conductors.* A conductor used as a grounded conductor shall be identifiable and distinguishable from all other conductors. A conductor used as an equipment grounding conductor shall be identifiable and distinguishable from all other conductors.

(2) *Polarity of connections.* No grounded conductor shall be attached to any terminal or lead so as to reverse designated polarity.

(3) *Use of grounding terminals and devices.* A grounding terminal or grounding-type device on a receptacle, cord connector, or attachment plug shall not be used for purposes other than grounding.

(b) *Branch circuits.*—(1) *Ground-fault protection.*—(i) *General.* The employer shall use either ground-fault circuit interrupters as specified in paragraph (b)(1)(ii) of this section or an assured equipment grounding conductor program as specified in paragraph (b)(1)(iii) of this section to protect employees on construction sites. These requirements are in addition to any other requirements for equipment grounding conductors.

(ii) *Ground-fault circuit interrupters.* All 120-volt, single-phase, 15- and 20-ampere receptacle outlets on construction sites, which are not a part of the permanent wiring of the building or structure and which are in use by employees, shall have approved ground-fault circuit interrupters for personnel protection. Receptacles on a two-wire, single-phase portable or vehicle-mounted generator rated not more than 5kW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with ground-fault circuit interrupters.

(iii) *Assured equipment grounding conductor program.* The employer shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, receptacles which are not a part of the building or structure, and equipment connected by cord and plug which are available for use or used by employees. This program shall comply with the following minimum requirements:

(A) A written description of the program, including the specific procedures adopted by the employer, shall be available at the jobsite for inspection and copying by the Assistant Secretary and any affected employee.

(B) The employer shall designate one or more competent persons (as defined in § 1926.32(f)) to implement the program.

(C) Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indications of possible internal damage. Equipment found damaged or defective shall not be used until repaired.

(D) The following tests shall be performed on all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and cord- and plug-connected equipment required to be grounded:

(*1*) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.

(*2*) Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor. The equipment grounding conductor shall be connected to its proper terminal.

(E) All required tests shall be performed:

(1) Before first use;

(2) Before equipment is returned to service following any repairs;

(3) Before equipment is used after any incident which can be reasonably suspected to have caused damage (for example, when a cord set is run over); and

(4) At intervals not to exceed 3 months, except that cord sets and receptacles which are fixed and not exposed to damage shall be tested at intervals not exceeding 6 months.

(F) The employer shall not make available or permit the use by employees of any equipment which has not met the requirements of this paragraph (b)(1)(iii) of this section.

(G) Tests performed as required in this paragraph shall be recorded. This test record shall identify each receptacle, cord set, and cord- and plug-connected equipment that passed the test and shall indicate the last date it was tested or the interval for which it was tested. This record shall be kept by means of logs, color coding, or other effective means and shall be maintained until replaced by a more current record. The record shall be made available on the jobsite for inspection by the Assistant Secretary and any affected employee.

(2) *Outlet devices.* Outlet devices shall have an ampere rating not less than the load to be served and shall comply with the following:

(i) *Single receptacles.* A single receptacle installed on an individual branch circuit shall have an ampere rating of not less than that of the branch circuit.

(ii) *Two or more receptacles.* Where connected to a branch circuit supply two or more receptacles or outlets, receptacle ratings shall conform to the values listed in Table K-4.

(iii) *Receptacles used for the connection of motors.* The rating of an attachment plug or receptacle used for cord- and plug-connection of a motor to a branch circuit shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts if individual overload protection is omitted.

(c) *Outside conductors and lamps*—(1) *600 volts, nominal, or less.* Paragraphs (c)(l)(i) through (c)(l)(iv) of this section apply to branch circuit, feeder, and service conductors rated 600 volts, nominal, or less and run outdoors as open conductors.

TABLE K-4—RECEPTACLE RATINGS FOR VARIOUS SIZE CIRCUITS

Circuit rating amperes	Receptacle rating amperes
15	Not over 15
20	15 or 20
30	30
40	40 or 50
50	50

(i) *Conductors on poles.* Conductors supported on poles shall provide a horizontal climbing space not less than the following:

(A) Power conductors below communication conductors—30 inches (762 mm).

(B) Power conductors alone or above communication conductors: 300 volts or less—24 inches (610 mm); more than 300 volts—30 inches (762 mm).

(C) Communication conductors below power conductors: with power conductors 300 volts or less—24 inches (610 mm); more than 300 volts—30 inches (762 mm).

(ii) *Clearance from ground.* Open conductors shall conform to the following minimum clearances:

(A) 10 feet (3.05 m)—above finished grade, sidewalks, or from any platform or projection from which they might be reached.

(B) 12 feet (3.66 m)—over areas subject to vehicular traffic other than truck traffic.

(C) 15 feet (4.57 m)—over areas other than those specified in paragraph (c)(l)(ii)(D) of this section that are subject to truck traffic.

(D) 18 feet (5.49 m)—over public streets, alleys, roads, and driveways.

(iii) *Clearance from building openings.* Conductors shall have a clearance of at least 3 feet (914 mm) from windows, doors, fire escapes, or similar locations. Conductors run above the top level of a window are considered to be out of reach from that window and, therefore, do not have to be 3 feet (914 mm) away.

(iv) *Clearance over roofs.* Conductors above roof space accessible to employees on foot shall have a clearance from the highest point of the roof surface of

not less than 8 feet (2.44 m) vertical clearance for insulated conductors, not less than 10 feet (3.05 m) vertical or diagonal clearance for covered conductors, and not less than 15 feet (4.57 m) for bare conductors, except that:

(A) Where the roof space is also accessible to vehicular traffic, the vertical clearance shall not be less than 18 feet (5.49 m), or

(B) Where the roof space is not normally accessible to employees on foot, fully insulated conductors shall have a vertical or diagonal clearance of not less than 3 feet (914 mm), or

(C) Where the voltage between conductors is 300 volts or less and the roof has a slope of not less than 4 inches (102 mm) in 12 inches (305 mm), the clearance from roofs shall be at least 3 feet (914 mm), or

(D) Where the voltage between conductors is 300 volts or less and the conductors do not pass over more than 4 feet (1.22 m) of the overhang portion of the roof and they are terminated at a through-the-roof raceway or support, the clearance from roofs shall be at least 18 inches (457 mm).

2 *Location of outdoor lamps.* Lamps for outdoor lighting shall be located below all live conductors, transformers, or other electric equipment, unless such equipment is controlled by a disconnecting means that can be locked in the open position or unless adequate clearances or other safeguards are provided for relamping operations.

(d) *Services*—(1) *Disconnecting means*—(i) *General.* Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors. The disconnecting means shall plainly indicate whether it is in the open or closed position and shall be installed at a readily accessible location nearest the point of entrance of the service-entrance conductors.

(ii) *Simultaneous opening of poles.* Each service disconnecting means shall simultaneously disconnect all ungrounded conductors.

(2) *Services over 600 volts, nominal.* The following additional requirements apply to services over 600 volts, nominal.

(i) *Guarding.* Service-entrance conductors installed as open wires shall be guarded to make them accessible only to qualified persons.

(ii) *Warning signs.* Signs warning of high voltage shall be posted where unauthorized employees might come in contact with live parts.

(e) *Overcurrent protection*—(1) *600 volts, nominal, or less.* The following requirements apply to overcurrent protection of circuits rated 600 volts, nominal, or less.

(i) *Protection of conductors and equipment.* Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current. Conductors shall have sufficient ampacity to carry the load.

(ii) *Grounded conductors.* Except for motor-running overload protection, overcurrent devices shall not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously.

(iii) *Disconnection of fuses and thermal cutouts.* Except for devices provided for current-limiting on the supply side of the service disconnecting means, all cartridge fuses which are accessible to other than qualified persons and all fuses and thermal cutouts on circuits over 150 volts to ground shall be provided with disconnecting means. The disconnecting means shall be installed so that the fuse or thermal cutout can be disconnected from its supply without disrupting service to equipment and circuits unrelated to those protected by the overcurrent device.

(iv) *Location in or on premises.* Overcurrent devices shall be readily accessible. Overcurrent devices shall not be located where they could create an employee safety hazard by being exposed to physical damage or located in the vicinity of easily ignitible material.

(v) *Arcing or suddenly moving parts.* Fuses and circuit breakers shall be so located or shielded that employees will not be burned or otherwise injured by their operation.

(vi) *Circuit breakers.* (A) Circuit breakers shall clearly indicate whether they are in the open (off) or closed (on) position.

(B) Where circuit breaker handles on

switchboards are operated vertically rather than horizontally or rotationally, the up position of the handle shall be the closed (on) position.

(C) If used as switches in 120-volt, fluorescent lighting circuits, circuit breakers shall be marked "SWD."

(2) *Over 600 volts, nominal.* Feeders and branch circuits over 600 volts, nominal, shall have short-circuit protection.

(f) *Grounding.* Paragraphs (f)(1) through (f)(11) of this section contain grounding requirements for systems, circuits, and equipment.

(1) *Systems to be grounded.* The following systems which supply premises wiring shall be grounded:

(i) *Three-wire DC systems.* All 3-wire DC systems shall have their neutral conductor grounded.

(ii) *Two-wire DC systems.* Two-wire DC systems operating at over 50 volts through 300 volts between conductors shall be grounded unless they are rectifier-derived from an AC system complying with paragraphs (f)(1)(iii), (f)(1)(iv), and (f)(1)(v) of this section.

(iii) *AC circuits, less than 50 volts.* AC circuits of less than 50 volts shall be grounded if they are installed as overhead conductors outside of buildings or if they are supplied by transformers and the transformer primary supply system is ungrounded or exceeds 150 volts to ground.

(iv) *AC systems, 50 volts to 1000 volts.* AC systems of 50 volts to 1000 volts shall be grounded under any of the following conditions, unless exempted by paragraph (f)(1)(v) of this section:

(A) If the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts;

(B) If the system is nominally rated 480Y/277 volt, 3-phase, 4-wire in which the neutral is used as a circuit conductor;

(C) If the system is nominally rated 240/120-volt, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor; or

(D) If a service conductor is uninsulated.

(v) *Exceptions.* AC systems of 50 volts to 1000 volts are not required to be grounded if the system is separately derived and is supplied by a transformer that has a primary voltage rating less than 1000 volts, provided all of the following conditions are met:

(A) The system is used exclusively for control circuits,

(B) The conditions of maintenance and supervision assure that only qualified persons will service the installation,

(C) Continuity of control power is required, and

(D) Ground detectors are installed on the control system.

(2) *Separately derived systems.* Where paragraph (f)(1) of this section requires grounding of wiring systems whose power is derived from generator, transformer, or converter windings and has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system, paragraphs (f)(5) of this section shall also apply.

(3) *Portable and vehicle-mounted generators*—(i) *Portable generators.* Under the following conditions, the frame of a portable generator need not be grounded and may serve as the grounding electrode for a system supplied by the generator:

(A) The generator supplies only equipment mounted on the generator and/or cord- and plug-connected equipment through receptacles mounted on the generator, and

(B) The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame.

(ii) *Vehicle-mounted generators.* Under the following conditions the frame of a vehicle may serve as the grounding electrode for a system supplied by a generator located on the vehicle:

(A) The frame of the generator is bonded to the vehicle frame, and

(B) The generator supplies only equipment located on the vehicle and/or cord- and plug-connected equipment through receptacles mounted on the vehicle or on the generator, and

(C) The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame, and

(D) The system complies with all other provisions of this section.

(iii) *Neutral conductor bonding.* A neutral conductor shall be bonded to the generator frame if the generator is a component of a separately derived system. No other conductor need be bonded to the generator frame.

(4) *Conductors to be grounded.* For AC premises wiring systems the identified conductor shall be grounded.

(5) *Grounding connections*—(i) *Grounded system.* For a grounded system, a grounding electrode conductor shall be used to connect both the equipment grounding connector and the grounded circuit conductor to the grounding electrode. Both the equipment grounding conductor and the grounding electrode conductor shall be connected to the grounded circuit conductor on the supply side of the service disconnecting means, or on the supply side of the system disconnecting means or overcurrent devices if the system is separately derived.

(ii) *Ungrounded systems.* For an ungrounded service-supplied system, the equipment grounding conductor shall be connected to the grounding electrode conductor at the service equipment. For an ungrounded separately derived system, the equipment grounding conductor shall be connected to the grounding electrode conductor at, or ahead of, the system disconnecting means or overcurrent devices.

(6) *Grounding path.* The path to ground from circuits, equipment, and enclosures shall be permanent and continuous.

(7) *Supports, enclosures, and equipment to be grounded*—(i) *Supports and enclosures for conductors.* Metal cable trays, metal raceways, and metal enclosures for conductors shall be grounded, except that:

(A) Metal enclosures such as sleeves that are used to protect cable assemblies from physical damage need not be grounded; and

(B) Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable need not be grounded if all of the following conditions are met:

(*1*) Runs are less than 25 feet (7.62 m);

(*2*) Enclosures are free from probable contact with ground, grounded metal, metal laths, or other conductive materials; and

(*3*) Enclosures are guarded against employee contact.

(ii) *Service equipment enclosures.* Metal enclosures for service equipment shall be grounded.

(iii) *Fixed equipment.* Exposed noncurrent-carrying metal parts of fixed equipment which may become energized shall be grounded under any of the following conditions:

(A) If within 8 feet (2.44 m) vertically or 5 feet (1.52 m) horizontally of ground or grounded metal objects and subject to employee contact.

(B) If located in a wet or damp location and subject to employee contact.

(C) If in electrical contact with metal.

(D) If in a hazardous (classified) location.

(E) If supplied by a metal-clad, metal-sheathed, or grounded metal raceway wiring method.

(F) If equipment operates with any terminal at over 150 volts to ground; however, the following need not be grounded:

(*1*) Enclosures for switches or circuit breakers used for other than service equipment and accessible to qualified persons only;

(*2*) Metal frames of electrically heated appliances which are permanently and effectively insulated from ground; and

(*3*) The cases of distribution apparatus such as transformers and capacitors mounted on wooden poles at a height exceeding 8 feet (2.44 m) above ground or grade level.

(iv) *Equipment connected by cord and plug.* Under any of the conditions described in paragraphs (f)(7)(iv)(A) through (f)(7)(iv)(C) of this section, exposed noncurrent-carrying metal parts of cord- and plug-connected equipment which may become energized shall be grounded:

(A) If in a hazardous (classified) location (see § 1926.407).

(B) If operated at over 150 volts to ground, except for guarded motors and metal frames of electrically heated appliances if the appliance frames are permanently and effectively insulated from ground.

(C) If the equipment is one of the

types listed in paragraphs (f)(7)(iv)(C)(*1*) through (f)(7)(iv)(C)(*5*) of this section. However, even though the equipment may be one of these types, it need not be grounded if it is exempted by paragraph (f)(7)(iv)(C)(*6*).

(*1*) Hand held motor-operated tools;

(*2*) Cord- and plug-connected equipment used in damp or wet locations or by employees standing on the ground or on metal floors or working inside of metal tanks or boilers;

(*3*) Portable and mobile X-ray and associated equipment;

(*4*) Tools likely to be used in wet and/or conductive locations; and

(*5*) Portable hand lamps.

(*6*) Tools likely to be used in wet and/or conductive locations need not be grounded if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts. Listed or labeled portable tools and appliances protected by a system of double insulation, or its equivalent, need not be grounded. If such a system is employed, the equipment shall be distinctively marked to indicate that the tool or appliance utilizes a system of double insulation.

(v) *Nonelectrical equipment.* The metal parts of the following nonelectrical equipment shall be grounded: frames and tracks of electrically operated cranes; frames of nonelectricallv driven elevator cars to which electric conductors are attached; hand-operated metal shifting ropes or cables of electric elevators, and metal partitions, grill work, and similar metal enclosures around equipment of over 1kV between conductors.

(8) *Methods of grounding equipment*—(i) *With circuit conductors.* Noncurrent-carrying metal parts of fixed equipment, if required to be grounded by this subpart, shall be grounded by an equipment grounding conductor which is contained within the same raceway, cable, or cord, or runs with or encloses the circuit conductors. For DC circuits only, the equipment grounding conductor may be run separately from the circuit conductors.

(ii) *Grounding conductor.* A conductor used for grounding fixed or movable equipment shall have capacity to conduct safely any fault current which may be imposed on it.

(iii) *Equipment considered effectively grounded.* Electric equipment is considered to be effectively grounded if it is secured to, and in electrical contact with, a metal rack or structure that is provided for its support and the metal rack or structure is grounded by the method specified for the noncurrent-carrying metal parts of fixed equipment in paragraph (f)(8)(i) of this section. Metal car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines are also considered to be effectively grounded.

(9) *Bonding.* If bonding conductors are used to assure electrical continuity, they shall have the capacity to conduct any fault current which may be imposed.

(10) *Made electrodes.* If made electrodes are used, they shall be free from nonconductive coatings, such as paint or enamel; and, if practicable, they shall be embedded below permanent moisture level. A single electrode consisting of a rod, pipe or plate which has a resistance to ground greater than 25 ohms shall be augmented by one additional electrode installed no closer than 6 feet (1.83 m) to the first electrode.

(11) *Grounding of systems and circuits of 1000 volts and over (high voltage)*—(i) *General.* If high voltage systems are grounded, they shall comply with all applicable provisions of paragraphs (f)(1) through (f)(10) of this section as supplemented and modified by this paragraph (f)(11).

(ii) *Grounding of systems supplying portable or mobile equipment.* Systems supplying portable or mobile high voltage equipment, other than substations installed on a temporary basis, shall comply with the following:

(A) Portable and mobile high voltage equipment shall be supplied from a system having its neutral grounded through an impedance. If a delta-connected high voltage system is used to supply the equipment, a system neutral shall be derived.

(B) Exposed noncurrent-carrying metal parts of portable and mobile equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.

(C) Ground-fault detection and relaying shall be provided to automatically de-energize any high voltage system component which has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to de-energize automatically the high voltage feeder to the portable equipment upon loss of continuity of the equipment grounding conductor.

(D) The grounding electrode to which the portable or mobile equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 feet (6.1 m) from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe, fence or like objects.

(iii) *Grounding of equipment.* All noncurrent-carrying metal parts of portable equipment and fixed equipment including those associated fences, housings, enclosures, and supporting structures shall be grounded. However, equipment which is guarded by location and isolated from ground need not be grounded. Additionally, pole-mounted distribution apparatus at a height exceeding 8 feet (2.44 m) above ground or grade level need not be grounded.

(Information collection requirements contained in paragraphs (b)(1)(iii)(A) and (b)(1)(iii)(G) were approved by the Office of Management and Budget under control number: 1218-0062; information collection requirements contained in paragraph (f)(7)(iv)(C)(6) were approved by the Office of Management and Budget under control number: 1218-0130)

§ 1926.405 Wiring methods, components, and equipment for general use.

(a) *Wiring methods.* The provisions of this paragraph do not apply to conductors which form an integral part of equipment such as motors, controllers, motor control centers and like equipment.

(1) *General requirements.*—(i) *Electrical continuity of metal raceways and enclosures.* Metal raceways, cable armor, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity.

(ii) *Wiring in ducts.* No wiring systems of any type shall be installed in ducts used to transport dust, loose stock or flammable vapors. No wiring system of any type shall be installed in any duct used for vapor removal or in any shaft containing only such ducts.

(2) *Temporary wiring*—(i) *Scope.* The provisions of paragraph (a)(2) of this section apply to temporary electrical power and lighting wiring methods which may be of a class less than would be required for a permanent installation. Except as specifically modified in paragraph (a)(2) of this section, all other requirements of this subpart for permanent wiring shall apply to temporary wiring installations. Temporary wiring shall be removed immediately upon completion of construction or the purpose for which the wiring was installed.

(ii) *General requirements for temporary wiring.* (A) Feeder shall originate in a distribution center. The conductors shall be run as multiconductor cord or cable assemblies or within raceways; or, where not subject to physical damage, they may be run as open conductors on insulators not more than 10 feet (3.05 m) apart.

(B) Branch circuits shall originate in a power outlet or panelboard. Conductors shall be run as multiconductor cord or cable assemblies or open conductors, or shall be run in raceways. All conductors shall be protected by overcurrent devices at their ampacity. Runs of open conductors shall be located where the conductors will not be subject to physical damage, and the conductors shall be fastened at intervals not exceeding 10 feet (3.05 m). No branch-circuit conductors shall be laid on the floor. Each branch circuit that supplies receptacles or fixed equipment shall contain a separate equipment grounding conductor if the branch circuit is run as open conductors.

(C) Receptacles shall be of the grounding type. Unless installed in a complete metallic raceway, each branch circuit shall contain a separate equipment grounding conductor, and all receptacles shall be electrically connected to the grounding conductor. Receptacles for uses other than temporary lighting

shall not be installed on branch circuits which supply temporary lighting. Receptacles shall not be connected to the same ungrounded conductor of multiwire circuits which supply temporary lighting.

(D) Disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

(E) All lamps for general illumination shall be protected from accidental contact or breakage. Metal-case sockets shall be grounded.

(F) Temporary lights shall not be suspended by their electric cords unless cords and lights are designed for this means of suspension.

(G) Portable electric lighting used in wet and/or other conductive locations, as for example, drums, tanks, and vessels, shall be operated at 12 volts or less. However, 120-volt lights may be used if protected by a ground-fault circuit interrupter.

(H) A box shall be used wherever a change is made to a raceway system or a cable system which is metal clad or metal sheathed.

(I) Flexible cords and cables shall be protected from damage. Sharp corners and projections shall be avoided. Flexible cords and cables may pass through doorways or other pinch points, if protection is provided to avoid damage.

(J) Extension cord sets used with portable electric tools and appliances shall be of three-wire type and shall be designed for hard or extra-hard usage. Flexible cords used with temporary and portable lights shall be designed for hard or extra-hard usage.

NOTE: The National Electrical Code, ANSI/NFPA 70, in Article 400, Table 400-4, lists various types of flexible cords, some of which are noted as being designed for hard or extra-hard usage. Examples of these types of flexible cords include hard service cord (types S, ST, SO, STO) and junior hard service cord (types SJ, SJO, SJT, SJTO).

(iii) *Guarding.* For temporary wiring over 600 volts, nominal, fencing, barriers, or other effective means shall be provided to prevent access of other than authorized and qualified personnel.

(b) *Cabinets, boxes, and fittings*—(1) *Conductors entering boxes, cabinets, or fittings.* Conductors entering boxes, cabinets, or fittings shall be protected from abrasion, and openings through which conductors enter shall be effectively closed. Unused openings in cabinets, boxes, and fittings shall also be effectively closed.

(2) *Covers and canopies.* All pull boxes, junction boxes, and fittings shall be provided with covers. If metal covers are used, they shall be grounded. In energized installations each outlet box shall have a cover, faceplate, or fixture canopy. Covers of outlet boxes having holes through which flexible cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear.

(3) *Pull and junction boxes for systems over 600 volts, nominal.* In addition to other requirements in this section for pull and junction boxes, the following shall apply to these boxes for systems over 600 volts, nominal:

(i) *Complete enclosure.* Boxes shall provide a complete enclosure for the contained conductors or cables.

(ii) *Covers.* Boxes shall be closed by covers securely fastened in place. Underground box covers that weigh over 100 pounds (43.6 kg) meet this requirement. Covers for boxes shall be permanently marked "HIGH VOLTAGE." The marking shall be on the outside of the box cover and shall be readily visible and legible.

(c) *Knife switches.* Single-throw knife switches shall be so connected that the blades are dead when the switch is in the open position. Single-throw knife switches shall be so placed that gravity will not tend to close them. Single-throw knife switches approved for use in the inverted position shall be provided with a locking device that will ensure that the blades remain in the open position when so set. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal. However, if the throw is vertical, a locking device shall be provided to ensure that the blades remain in the open position when so set.

(d) *Switchboards and panelboards.* Switchboards that have any exposed live parts shall be located in permanently dry locations and accessible only to qualified persons. Panelboards shall

be mounted in cabinets, cutout boxes, or enclosures designed for the purpose and shall be dead front. However, panelboards other than the dead front externally-operable type are permitted where accessible only to qualified persons. Exposed blades of knife switches shall be dead when open.

(e) *Enclosures for damp or wet locations*—(1) *Cabinets, fittings, and boxes.* Cabinets, cutout boxes, fittings, boxes, and panelboard enclosures in damp or wet locations shall be installed so as to prevent moisture or water from entering and accumulating within the enclosures. In wet locations the enclosures shall be weatherproof.

(2) *Switches and circuit breakers.* Switches, circuit breakers, and switchboards installed in wet locations shall be enclosed in weatherproof enclosures.

(f) *Conductors for general wiring.* All conductors used for general wiring shall be insulated unless otherwise permitted in this Subpart. The conductor insulation shall be of a type that is suitable for the voltage, operating temperature, and location of use. Insulated conductors shall be distinguishable by appropriate color or other means as being grounded conductors, ungrounded conductors, or equipment grounding conductors.

(g) *Flexible cords and cables*—(1) *Use of flexible cords and cables*—(i) *Permitted uses.* Flexible cords and cables shall be suitable for conditions of use and location. Flexible cords and cables shall be used only for:

(A) Pendants;

(B) Wiring of fixtures;

(C) Connection of portable lamps or appliances;

(D) Elevator cables;

(E) Wiring of cranes and hoists;

(F) Connection of stationary equipment to facilitate their frequent interchange;

(G) Prevention of the transmission of noise or vibration; or

(H) Appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair.

(ii) *Attachment plugs for cords.* If used as permitted in paragraphs (g)(1)(i)(C), (G)(1)(i)(F), or (g)(1)(i)(H) of this section, the flexible cord shall be equipped with an attachment plug and shall be energized from a receptacle outlet.

(iii) *Prohibited uses.* Unless necessary for a use permitted in paragraph (g)(1)(i) of this section, flexible cords and cables shall not be used:

(A) As a substitute for the fixed wiring of a structure;

(B) Where run through holes in walls, ceilings, or floors;

(C) Where run through doorways, windows, or similar openings, except as permitted in paragraph (a)(2)(ii)(I) of this section;

(D) Where attached to building surfaces; or

(E) Where concealed behind building walls, ceilings, or floors.

(2) *Identification, splices, and terminations*—(i) *Identification.* A conductor of a flexible cord or cable that is used as a grounded conductor or an equipment grounding conductor shall be distinguishable from other conductors.

(ii) *Marking.* Type SJ, SJO, SJT, SJTO, S, SO, ST, and STO cords shall not be used unless durably marked on the surface with the type designation, size, and number of conductors.

(iii) *Splices.* Flexible cords shall be used only in continuous lengths without splice or tap. Hard service flexible cords No. 12 or larger may be repaired if spliced so that the splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

(iv) *Strain relief.* Flexible cords shall be connected to devices and fittings so that strain relief is provided which will prevent pull from being directly transmitted to joints or terminal screws.

(v) *Cords passing through holes.* Flexible cords and cables shall be protected by bushings or fittings where passing through holes in covers, outlet boxes, or similar enclosures.

(h) *Portable cables over 600 volts, nominal.* Multiconductor portable cable for use in supplying power to portable or mobile equipment at over 600 volts, nominal, shall consist of No. 8 or larger conductors employing flexible stranding. Cables operated at over 2000 volts shall be shielded for the purpose of confining the voltage stresses to the insulation. Grounding conductors shall be provided.

Connectors for these cables shall be of a locking type with provisions to prevent their opening or closing while energized. Strain relief shall be provided at connections and terminations. Portable cables shall not be operated with splices unless the splices are of the permanent molded, vulcanized, or other equivalent type. Termination enclosures shall be marked with a high voltage hazard warning, and terminations shall be accessible only to authorized and qualified personnel.

(i) *Fixture wires*—(1) *General.* Fixture wires shall be suitable for the voltage, temperature, and location of use. A fixture wire which is used as a grounded conductor shall be identified.

(2) *Uses permitted.* Fixture wires may be used:

(i) For installation in lighting fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use; or

(ii) For connecting lighting fixtures to the branch-circuit conductors supplying the fixtures.

(3) *Uses not permitted.* Fixture wires shall not be used as branch-circuit conductors except as permitted for Class 1 power-limited circuits.

(j) *Equipment for general use*—(1) *Lighting fixtures, lampholders, lamps, and receptacles*—(i) *Live parts.* Fixtures, lampholders, lamps, rosettes, and receptacles shall have no live parts normally exposed to employee contact. However, rosettes and cleat-type lampholders and receptacles located at least 8 feet (2.44 m) above the floor may have exposed parts.

(ii) *Support.* Fixtures, lampholders, rosettes, and receptacles shall be securely supported. A fixture that weighs more than 6 pounds (2.72 kg) or exceeds 16 inches (406 mm) in any dimension shall not be supported by the screw shell of a lampholder.

(iii) *Portable lamps.* Portable lamps shall be wired with flexible cord and an attachment plug of the polarized or grounding type. If the portable lamp uses an Edison-based lampholder, the grounded conductor shall be identified and attached to the screw shell and the identified blade of the attachment plug. In addition, portable handlamps shall comply with the following:

(A) Metal shell, paperlined lampholders shall not be used;

(B) Handlamps shall be equipped with a handle of molded composition or other insulating material;

(C) Handlamps shall be equipped with a substantial guard attached to the lampholder or handle;

(D) Metallic guards shall be grounded by the means of an equipment grounding conductor run within the power supply cord.

(iv) *Lampholders.* Lampholders of the screw-shell type shall be installed for use as lampholders only. Lampholders installed in wet or damp locations shall be of the weatherproof type.

(v) *Fixtures.* Fixtures installed in wet or damp locations shall be identified for the purpose and shall be installed so that water cannot enter or accumulate in wireways, lampholders, or other electrical parts.

(2) *Receptacles, cord connectors, and attachment plugs (caps)*—(i) *Configuration.* Receptacles, cord connectors, and attachment plugs shall be constructed so that no receptacle or cord connector will accept an attachment plug with a different voltage or current rating than that for which the device is intended. However, a 20-ampere T-slot receptacle or cord connector may accept a 15-ampere attachment plug of the same voltage rating. Receptacles connected to circuits having different voltages, frequencies, or types of current (ac or dc) on the same premises shall be of such design that the attachment plugs used on these circuits are not interchangeable.

(ii) *Damp and wet locations.* A receptacle installed in a wet or damp location shall be designed for the location.

(3) *Appliances*—(i) *Live parts.* Appliances, other than those in which the current-carrying parts at high temperatures are necessarily exposed, shall have no live parts normally exposed to employee contact.

(ii) *Disconnecting means.* A means shall be provided to disconnect each appliance.

(iii) *Rating.* Each appliance shall be marked with its rating in volts and amperes or volts and watts.

(4) *Motors.* This paragraph applies to

motors, motor circuits, and controllers.

(i) *In sight from.* If specified that one piece of equipment shall be "in sight from" another piece of equipment, one shall be visible and not more than 50 feet (15.2 m) from the other.

(ii) *Disconnecting means*—(A) A disconnecting means shall be located in sight from the controller location. The controller disconnecting means for motor branch circuits over 600 volts, nominal, may be out of sight of the controller, if the controller is marked with a warning label giving the location and identification of the disconnecting means which is to be locked in the open position.

(B) The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently.

(C) If a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

(*1*) The controller disconnecting means shall be capable of being locked in the open position.

(*2*) A manually operable switch that will disconnect the motor from its source of supply shall be placed in sight from the motor location.

(D) The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

(E) The disconnecting means shall be readily accessible. If more than one disconnect is provided for the same equipment, only one need be readily accessible.

(F) An individual disconnecting means may be used for a group of motors under any one of the following conditions:

(*1*) If a number of motors drive special parts of a single machine or piece of apparatus, such as a metal or woodworking machine, crane, or hoist;

(*2*) If a group of motors is under the protection of one set of branch-circuit protective devices; or

(*3*) If a group of motors is in a single room in sight from the location of the disconnecting means.

(iii) *Motor overload, short-circuit, and ground-fault protection.* Motors, motor-control apparatus, and motor branch-circuit conductors shall be protected against overheating due to motor overloads or failure to start, and against short-circuits or ground faults. These provisions do not require overload protection that will stop a motor where a shutdown is likely to introduce additional or increased hazards, as in the case of fire pumps, or where continued operation of a motor is necessary for a safe shutdown of equipment or process and motor overload sensing devices are connected to a supervised alarm.

(iv) *Protection of live parts—all voltages.* (A) Stationary motors having commutators, collectors, and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground need not have such parts guarded. Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded against accidental contact by any of the following:

(*1*) By installation in a room or enclosure that is accessible only to qualified persons;

(*2*) By installation on a balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons; or

(*3*) By elevation 8 feet (2.44 m) or more above the floor.

(B) Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location, and where adjustment or other attendance may be necessary during the operation of the apparatus, insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

(5) *Transformers*—(i) *Application.* The following paragraphs cover the installation of all transformers, except:

(A) Current transformers;

(B) Dry-type transformers installed as a component part of other apparatus;

(C) Transformers used with Class 2 and Class 3 circuits, sign and outline lighting, electric discharge lighting, and power-limited fire-protective signaling circuits.

(ii) *Operating voltage.* The operating voltage of exposed live parts of transformer installations shall be indicated

by warning signs or visible markings on the equipment or structure.

(iii) *Transformers over 35 kV.* Dry-type, high fire point liquid-insulated, and askarel-insulated transformers installed indoors and rated over 35 kV shall be in a vault.

(iv) *Oil-insulated transformers.* If they present a fire hazard to employees, oil-insulated transformers installed indoors shall be in a vault.

(v) *Fire protection.* Combustible material, combustible buildings and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires which may originate in oil-insulated transformers attached to or adjacent to a building or combustible material.

(vi) *Transformer vaults.* Transformer vaults shall be constructed so as to contain fire and combustible liquids within the vault and to prevent unauthorized access. Locks and latches shall be so arranged that a vault door can be readily opened from the inside.

(vii) *Pipes and ducts.* Any pipe or duct system foreign to the vault installation shall not enter or pass through a transformer vault.

(viii) *Material storage.* Materials shall not be stored in transformer vaults.

(6) *Capacitors*—(i) *Drainage of stored charge.* All capacitors, except surge capacitors or capacitors included as a component part of other apparatus, shall be provided with an automatic means of draining the stored charge and maintaining the discharged state after the capacitor is disconnected from its source of supply.

(ii) *Over 600 volts.* Capacitors rated over 600 volts, nominal, shall comply with the following additional requirements:

(A) Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load interrupting device or shall be provided with prominently displayed caution signs to prevent switching load current.

(B) For series capacitors the proper switching shall be assured by use of at least one of the following:

(*1*) Mechanically sequenced isolating and bypass switches,

(*2*) Interlocks, or

(*3*) Switching procedure prominently displayed at the switching location.

(Information collection requirements contained in paragraphs (g)(2)(ii), (j)(3)(iii), (j)(4)(ii)(A), (j)(5)(ii), and (j)(6)(ii)(B)(3) were approved by the Office of Management and Budget under control number: 1218-0130)

§ 1926.406 Specific purpose equipment and installations.

(a) *Cranes and hoists.* This paragraph applies to the installation of electric equipment and wiring used in connection with cranes, monorail hoists, hoists, and all runways.

(1) *Disconnecting means*—(i) *Runway conductor disconnecting means.* A readily accessible disconnecting means shall be provided between the runway contact conductors and the power supply.

(ii) *Disconnecting means for cranes and monorail hoists.* A disconnecting means, capable of being locked in the open position, shall be provided in the leads from the runway contact conductors or other power supply or any crane or monorail hoist.

(A) If this additional disconnecting means is not readily accessible from the crane or monorail hoist operating station, means shall be provided at the operating station to open the power circuit to all motors of the crane or monorail hoist.

(B) The additional disconnect may be omitted if a monorail hoist or hand-propelled crane bridge installation meets all of the following:

(*1*) The unit is floor controlled;

(*2*) The unit is within view of the power supply disconnecting means; and

(*3*) No fixed work platform has been provided for servicing the unit.

(2) *Control.* A limit switch or other device shall be provided to prevent the load block from passing the safe upper limit of travel of any hoisting mechanism.

(3) *Clearance.* The dimension of the working space in the direction of access to live parts which may require examination, adjustment, servicing, or maintenance while alive shall be a minimum of 2 feet 6 inches (762 mm). Where controls are enclosed in cabinets, the door(s) shall open at least 90 degrees or be removable, or the installation shall provide equivalent access.

(4) *Grounding.* All exposed metal parts of cranes, monorail hoists, hoists

and accessories including pendant controls shall be metallically joined together into a continuous electrical conductor so that the entire crane or hoist will be grounded in accordance with § 1926.404(f). Moving parts, other than removable accessories or attachments, having metal-to-metal bearing surfaces shall be considered to be electrically connected to each other through the bearing surfaces for grounding purposes. The trolley frame and bridge frame shall be considered as electrically grounded through the bridge and trolley wheels and its respective tracks unless conditions such as paint or other insulating materials prevent reliable metal-to-metal contact. In this case a separate bonding conductor shall be provided.

(b) *Elevators, escalators, and moving walks*—(1) *Disconnecting means.* Elevators, escalators, and moving walks shall have a single means for disconnecting all ungrounded main power supply conductors for each unit.

(2) *Control panels.* If control panels are not located in the same space as the drive machine, they shall be located in cabinets with doors or panels capable of being locked closed.

(c) *Electric welders—disconnecting means*—(1) *Motor-generator, AC transformer, and DC rectifier arc welders.* A disconnecting means shall be provided in the supply circuit for each motor-generator arc welder, and for each AC transformer and DC rectifier arc welder which is not equipped with a disconnect mounted as an integral part of the welder.

(2) *Resistance welders.* A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be isolated from the supply circuit. The ampere rating of this disconnecting means shall not be less than the supply conductor ampacity.

(d) *X-ray equipment*—(1) *Disconnecting means*—(i) *General.* A disconnecting means shall be provided in the supply circuit. The disconnecting means shall be operable from a location readily accessible from the X-ray control. For equipment connected to a 120-volt branch circuit of 30 amperes or less, a grounding-type attachment plug cap and receptacle of proper rating may serve as a disconnecting means.

(ii) *More than one piece of equipment.* If more than one piece of equipment is operated from the same high-voltage circuit, each piece or each group of equipment as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact by employees with its live parts.

(2) *Control. Radiographic and fluoroscopic types.* Radiographic- and fluoroscopic-type equipment shall be effectively enclosed or shall have interlocks that deenergize the equipment automatically to prevent ready access to live current-carrying parts.

§ 1926.407 Hazardous (classified) locations.

(a) *Scope.* This section sets forth requirements for electric equipment and wiring in locations which are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers which may be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Each room, section or area shall be considered individually in determining its classification. These hazardous (classified) locations are assigned six designations as follows:

Class I, Division 1
Class I, Division 2
Class II, Division 1
Class II, Division 2
Class III, Division 1
Class III, Division 2

For definitions of these locations see § 1926.449. All applicable requirements in this subpart apply to all hazardous (classified) locations, unless modified by provisions of this section.

(b) *Electrical installations.* Equipment, wiring methods, and installations of equipment in hazardous (classified) locations shall be approved as intrinsically safe or approved for the hazardous (classified) location or safe for the hazardous (classified) location. Requirements for each of these options are as follows:

(1) *Intrinsically safe.* Equipment and associated wiring approved as intrinsically safe is permitted in any hazardous (classified) location included in its listing or labeling.

(2) *Approved for the hazardous (classified) location*—(i) *General.* Equipment shall be approved not only for the class of location but also for the ignitible or combustible properties of the specific gas, vapor, dust, or fiber that will be present.

NOTE: NFPA 70, the National Electrical Code, lists or defines hazardous gases, vapors, and dusts by "Groups" characterized by their ignitible or combustible properties.

(ii) *Marking.* Equipment shall not be used unless it is marked to show the class, group, and operating temperature or temperature range, based on operation in a 40-degree C ambient, for which it is approved. The temperature marking shall not exceed the ignition temperature of the specific gas, vapor, or dust to be encountered. However, the following provisions modify this marking requirement for specific equipment:

(A) Equipment of the non-heat-producing type (such as junction boxes, conduit, and fittings) and equipment of the heat-producing type having a maximum temperature of not more than 100 degrees C (212 degrees F) need not have a marked operating temperature or temperature range.

(B) Fixed lighting fixtures marked for use only in Class I, Division 2 locations need not be marked to indicate the group.

(C) Fixed general-purpose equipment in Class I locations, other than lighting fixtures, which is acceptable for use in Class I, Division 2 locations need not be marked with the class, group, division, or operating temperature.

(D) Fixed dust-tight equipment, other than lighting fixtures, which is acceptable for use in Class II, Division 2 and Class III locations need not be marked with the class, group, division, or operating temperature.

(3) *Safe for the hazardous (classified) location.* Equipment which is safe for the location shall be of a type and design which the employer demonstrates will provide protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts, or fibers.

NOTE: The National Electrical Code, NFPA 70, contains guidelines for determining the type and design of equipment and installations which will meet this requirement. The guidelines of this document address electric wiring, equipment, and systems installed in hazardous (classified) locations and contain specific provisions for the following: wiring methods, wiring connections, conductor insulation, flexible cords, sealing and drainage, transformers, capacitors, switches, circuit breakers, fuses, motor controllers, receptacles, attachment plugs, meters, relays, instruments, resistors, generators, motors, lighting fixtures, storage battery charging equipment, electric cranes, electric hoists and similar equipment, utilization equipment, signaling systems, alarm systems, remote control systems, local loud speaker and communication systems, ventilation piping, live parts, lightning surge protection, and grounding. Compliance with these guidelines will constitute one means, but not the only means, of compliance with this paragraph.

(c) *Conduits.* All conduits shall be threaded and shall be made wrench-tight. Where it is impractical to make a threaded joint tight, a bonding jumper shall be utilized.

(Information collection requirements contained in paragraph (b)(2)(ii) were approved by the Office of Management and Budget under control number: 1218-0130)

§ 1926.408 Special systems.

(a) *Systems over 600 volts, nominal.* Paragraphs (a)(1) through (a)(4) of this section contain general requirements for all circuits and equipment operated at over 600 volts.

(1) *Wiring methods for fixed installations*—(i) *Above-ground.* Above-ground conductors shall be installed in rigid metal conduit, in intermediate metal conduit, in cable trays, in cablebus, in other suitable raceways, or as open runs of metal-clad cable designed for the use and purpose. However, open runs of non-metallic-sheathed cable or of bare conductors or busbars may be installed in locations which are accessible only to qualified persons. Metallic shielding components, such as tapes, wires, or braids for conductors, shall be grounded. Open runs of insulated wires and cables having a bare lead sheath or a braided outer covering shall be supported in a manner designed to prevent physical damage to the braid or sheath.

(ii) *Installations emerging from the ground.* Conductors emerging from the ground shall be enclosed in raceways.

Raceways installed on poles shall be of rigid metal conduit, intermediate metal conduit, PVC schedule 80 or equivalent extending from the ground line up to a point 8 feet (2.44 m) above finished grade. Conductors entering a building shall be protected by an enclosure from the ground line to the point of entrance. Metallic enclosures shall be grounded.

(2) *Interrupting and isolating devices*—(i) *Circuit breakers.* Circuit breakers located indoors shall consist of metal-enclosed or fire-resistant, cell-mounted units. In locations accessible only to qualified personnel, open mounting of circuit breakers is permitted. A means of indicating the open and closed position of circuit breakers shall be provided.

(ii) *Fused cutouts.* Fused cutouts installed in buildings or transformer vaults shall be of a type identified for the purpose. They shall be readily accessible for fuse replacement.

(iii) *Equipment isolating means.* A means shall be provided to completely isolate equipment for inspection and repairs. Isolating means which are not designed to interrupt the load current of the circuit shall be either interlocked with a circuit interrupter or provided with a sign warning against opening them under load.

(3) *Mobile and portable equipment*—(i) *Power cable connections to mobile machines.* A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include provisions for a solid connection for the ground wire(s) terminal to ground effectively the machine frame. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so only authorized qualified persons may open it and shall be marked with a sign warning of the presence of energized parts.

(ii) *Guarding live parts.* All energized switching and control parts shall be enclosed in effectively grounded metal cabinets or enclosures. Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosures so these units can be reset without locked doors being opened. Enclosures and metal cabinets shall be locked so that only authorized qualified persons have access and shall be marked with a sign warning of the presence of energized parts. Collector ring assemblies on revolving-type machines (shovels, draglines, etc.) shall be guarded.

(4) *Tunnel installations*—(i) *Application.* The provisions of this paragraph apply to installation and use of high-voltage power distribution and utilization equipment which is associated with tunnels and which is portable and/or mobile, such as substations, trailers, cars, mobile shovels, draglines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators.

(ii) *Conductors.* Conductors in tunnels shall be installed in one or more of the following:

(A) Metal conduit or other metal raceway,

(B) Type MC cable, or

(C) Other suitable multiconductor cable.

Conductors shall also be so located or guarded as to protect them from physical damage. Multiconductor portable cable may supply mobile equipment. An equipment grounding conductor shall be run with circuit conductors inside the metal raceway or inside the multiconductor cable jacket. The equipment grounding conductor may be insulated or bare.

(iii) *Guarding live parts.* Bare terminals of transformers, switches, motor controllers, and other equipment shall be enclosed to prevent accidental contact with energized parts. Enclosures for use in tunnels shall be drip-proof, weatherproof, or submersible as required by the environmental conditions.

(iv) *Disconnecting means.* A disconnecting means that simultaneously opens all ungrounded conductors shall be installed at each transformer or motor location.

(v) *Grounding and bonding.* All nonenergized metal parts of electric equipment and metal raceways and cable sheaths shall be grounded and bonded to all metal pipes and rails at the portal and at intervals not exceeding 1000 feet (305 m) throughout the tunnel.

(b) *Class 1, Class 2, and Class 3 remote control, signaling, and power-limited circuits*—(1) *Classification.* Class 1, Class 2, or Class 3 remote control, signaling, or power-limited circuits are characterized by their usage and electrical power limitation which differentiates them from light and power circuits. These circuits are classified in accordance with their respective voltage and power limitations as summarized in paragraphs (b)(1)(i) through (b)(1)(iii) of this section.

(i) *Class 1 circuits.*—(A) A class 1 power-limited circuit is supplied from a source having a rated output of not more than 30 volts and 1000 volt-amperes.

(B) A Class 1 remote control circuit or a Class 1 signaling circuit has a voltage which does not exceed 600 volts; however, the power output of the source need not be limited.

(ii) *Class 2 and Class 3 circuits.*—(A) Power for Class 2 and Class 3 circuits is limited either inherently (in which no overcurrent protection is required) or by a combination of a power source and overcurrent protection.

(B) The maximum circuit voltage is 150 volts AC or DC for a Class 2 inherently limited power source, and 100 volts AC or DC for a Class 3 inherently limited power source.

(C) The maximum circuit voltage is 30 volts AC and 60 volts DC for a Class 2 power source limited by overcurrent protection, and 150 volts AC or DC for a Class 3 power source limited by overcurrent protection.

(iii) *Application.* The maximum circuit voltages in paragraphs (b)(1)(i) and (b)(1)(ii) of this section apply to sinusoidal AC or continuous DC power sources, and where wet contact occurrence is not likely.

(2) *Marking.* A Class 2 or Class 3 power supply unit shall not be used unless it is durably marked where plainly visible to indicate the class of supply and its electrical rating.

(c) *Communications systems*—(1) *Scope.* These provisions for communication systems apply to such systems as central-station-connected and non-central-station-connected telephone circuits, radio receiving and transmitting equipment, and outside wiring for fire and burglar alarm, and similar central station systems. These installations need not comply with the provisions of §§ 1926.403 through 1926.408(b), except § 1926.404(c)(1)(ii) and § 1926.407.

(2) *Protective devices*—(i) *Circuits exposed to power conductors.* Communication circuits so located as to be exposed to accidental contact with light or power conductors operating at over 300 volts shall have each circuit so exposed provided with an approved protector.

(ii) *Antenna lead-ins.* Each conductor of a lead-in from an outdoor antenna shall be provided with an antenna discharge unit or other means that will drain static charges from the antenna system.

(3) *Conductor location*—(i) *Outside of buildings.*—(A) Receiving distribution lead-in or aerial-drop cables attached to buildings and lead-in conductors to radio transmitters shall be so installed as to avoid the possibility of accidental contact with electric light or power conductors.

(B) The clearance between lead-in conductors and any lightning protection conductors shall not be less than 6 feet (1.83 m).

(ii) *On poles.* Where practicable, communication conductors on poles shall be located below the light or power conductors. Communications conductors shall not be attached to a crossarm that carries light or power conductors.

(iii) *Inside of buildings.* Indoor antennas, lead-ins, and other communication conductors attached as open conductors to the inside of buildings shall be located at least 2 inches (50.8 mm) from conductors of any light or power or Class 1 circuits unless a special and equally protective method of conductor separation is employed.

(4) *Equipment location.* Outdoor metal structures supporting antennas, as well as self-supporting antennas such as vertical rods or dipole structures, shall be located as far away from overhead conductors of electric light and power circuits of over 150 volts to ground as necessary to avoid the possibility of the antenna or structure falling into or making accidental contact with such circuits.

(5) *Grounding*—(i) *Lead-in conductors.*

If exposed to contact with electric light or power conductors, the metal sheath of aerial cables entering buildings shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device. Where protective devices are used, they shall be grounded.

(ii) *Antenna structures.* Masts and metal structures supporting antennas shall be permanently and effectively grounded without splice or connection in the grounding conductor.

(iii) *Equipment enclosures.* Transmitters shall be enclosed in a metal frame or grill or separated from the operating space by a barrier, all metallic parts of which are effectively connected to ground. All external metal handles and controls accessible to the operating personnel shall be effectively grounded. Unpowered equipment and enclosures shall be considered grounded where connected to an attached coaxial cable with an effectively grounded metallic shield.

(Information collection requirements contained in paragraph (b)(2) were approved by the Office of Management and Budget under control number: 1218-0130)

§ 1926.409–§ 1926.415. [Reserved]

Safety-Related Work Practices

§ 1926.416 General requirements.

(a) *Protection of employees.* (1) No employer shall permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by deenergizing the circuit and grounding it or by guarding it effectively by insulation or other means.

(2) In work areas where the exact location of underground electric powerlines is unknown, employees using jack-hammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves.

(3) Before work is begun the employer shall ascertain by inquiry or direct observation, or by instruments, whether any part of an energized electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact with the electric power circuit. The employer shall post and maintain proper warning signs where such a circuit exists. The employer shall advise employees of the location of such lines, the hazards involved, and the protective measures to be taken.

(b) *Passageways and open spaces.* (1) Barriers or other means of guarding shall be provided to ensure that workspace for electrical equipment will not be used as a passageway during periods when energized parts of electrical equipment are exposed.

(2) Working spaces, walkways, and similar locations shall be kept clear of cords so as not to create a hazard to employees.

(c) *Load ratings.* In existing installations, no changes in circuit protection shall be made to increase the load in excess of the load rating of the circuit wiring.

(d) *Fuses.* When fuses are installed or removed with one or both terminals energized, special tools insulated for the voltage shall be used.

(e) *Cords and cables.* (1) Worn or frayed electric cords or cables shall not be used.

(2) Extension cords shall not be fastened with staples, hung from nails, or suspended by wire.

§ 1926.417 Lockout and tagging of circuits.

(a) *Controls.* Controls that are to be deactivated during the course of work on energized or deenergized equipment or circuits shall be tagged.

(b) *Equipment and circuits.* Equipment or circuits that are deenergized shall be rendered inoperative and shall have tags attached at all points where such equipment or circuits can be energized.

(c) *Tags.* Tags shall be placed to identify plainly the equipment or circuits being worked on.

§ 1926.418–§ 1926.430 [Reserved]

Safety-Related Maintenance and Environmental Considerations

§ 1926.431 Maintenance of equipment.

The employer shall ensure that all wiring components and utilization equip-

ment in hazardous locations are maintained in a dust-tight, dust-ignition-proof, or explosion-proof condition, as appropriate. There shall be no loose or missing screws, gaskets, threaded connections, seals, or other impairments to a tight condition.

§ 1926.432 Environmental deterioration of equipment.

(a) *Deteriorating agents.* (1) Unless identified for use in the operating environment, no conductors or equipment shall be located:

(i) In damp or wet locations;

(ii) Where exposed to gases, fumes, vapors, liquids, or other agents having a deteriorating effect on the conductors or equipment; or

(iii) Where exposed to excessive temperatures.

(2) Control equipment, utilization equipment, and busways approved for use in dry locations only shall be protected against damage from the weather during building construction.

(b) *Protection against corrosion.* Metal raceways, cable armor, boxes, cable sheathing, cabinets, elbows, couplings, fittings, supports, and support hardware shall be of materials appropriate for the environment in which they are to be installed.

§ 1926.433–§ 1926.440 [Reserved].

Safety Requirements for Special Equipment

§ 1926.441 Batteries and battery charging.

(a) *General requirements.* (1) Batteries of the unsealed type shall be located in enclosures with outside vents or in well ventilated rooms and shall be arranged so as to prevent the escape of fumes, gases, or electrolyte spray into other areas.

(2) Ventilation shall be provided to ensure diffusion of the gases from the battery and to prevent the accumulation of an explosive mixture.

(3) Racks and trays shall be substantial and shall be treated to make them resistant to the electrolyte.

(4) Floors shall be of acid resistant construction unless protected from acid accumulations.

(5) Face shields, aprons, and rubber gloves shall be provided for workers handling acids or batteries.

(6) Facilities for quick drenching of the eyes and body shall be provided within 25 feet (7.62 m) of battery handling areas.

(7) Facilities shall be provided for flushing and neutralizing spilled electrolyte and for fire protection.

(b) *Charging.* (1) Battery charging installations shall be located in areas designated for that purpose.

(2) Charging apparatus shall be protected from damage by trucks.

(3) When batteries are being charged, the vent caps shall be kept in place to avoid electrolyte spray. Vent caps shall be maintained in functioning condition.

§ 1926.442–§ 1926.448 [Reserved].

Definitions

§ 1926.449 Definitions applicable to this subpart.

The definitions given in this section apply to the terms used in Subpart K. The definitions given here for "approved" and "qualified person" apply, instead of the definitions given in § 1926.32, to the use of these terms in Subpart K.

Acceptable. An installation or equipment is acceptable to the Assistant Secretary of Labor, and approved within the meaning of this Subpart K:

(a) If it is accepted, or certified, or listed, or labeled, or otherwise determined to be safe by a qualified testing laboratory capable of determining the suitability of materials and equipment for installation and use in accordance with this standard; or

(b) With respect to an installation or equipment of a kind which no qualified testing laboratory accepts, certifies, lists, labels, or determines to be safe, if it is inspected or tested by another Federal agency, or by a State, municipal, or other local authority responsible for enforcing occupational safety provisions of the National Electrical Code, and found in compliance with those provisions; or

(c) With respect to custom-made equipment or related installations which are designed, fabricated for, and in-

tended for use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection to the Assistant Secretary and his authorized representatives.

Accepted. An installation is "accepted" if it has been inspected and found to be safe by a qualified testing laboratory.

Accessible. (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building. (See *"concealed"* and *"exposed."*)

Accessible. (As applied to equipment.) Admitting close approach; not guarded by locked doors, elevation, or other effective means. (See *"Readily accessible."*)

Ampacity. The current in amperes a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

Appliances. Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions.

Approved. Acceptable to the authority enforcing this Subpart. The authority enforcing this Subpart is the Assistant Secretary of Labor for Occupational Safety and Health. The definition of "acceptable" indicates what is acceptable to the Assistant Secretary of Labor, and therefore approved within the meaning of this Subpart.

Askarel. A generic term for a group of nonflammable synthetic chlorinated hydrocarbons used as electrical insulating media. Askarels of various compositional types are used. Under arcing conditions the gases produced, while consisting predominantly of noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type.

Attachment plug (Plug cap)(Cap). A device which, by insertion in a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

Automatic. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration.

Bare conductor. See *"Conductor."*

Bonding. The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Bonding jumper. A reliable conductor to assure the required electrical conductivity between metal parts required to be electrically connected.

Branch circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

Building. A structure which stands alone or which is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors.

Cabinet. An enclosure designed either for surface or flush mounting, and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung.

Certified. Equipment is "certified" if it:

(a) Has been tested and found by a qualified testing laboratory to meet applicable test standards or to be safe for use in a specified manner, and

(b) Is of a kind whose production is periodically inspected by a qualified testing laboraotory. Certified equipment must bear a label, tag, or other record of certification.

Circuit breaker. (a) (600 volts nominal, or less.) A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without injury to itself when properly applied within its rating.

(b) (Over 600 volts, nominal.) A switching device capable of making, carrying, and breaking currents under normal circuit conditions, and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions, such as those of short circuit.

Class I locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explo-

sive or ignitible mixtures. Class I locations include the following:

(a) *Class I, Division 1.* A Class I, Division 1 location is a location:

(1) In which ignitible concentrations of flammable gases or vapors may exist under normal operating conditions; or

(2) In which ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or

(3) In which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

NOTE: This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; and all other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

(b) *Class I, Division 2.* A Class I, Division 2 location is a location:

(1) In which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or

(2) In which ignitible concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment; or

(3) That is adjacent to a Class I, Division 1 location, and to which ignitible concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

NOTE: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Division 2 location if the outside of the conduit and enclosures is a nonhazardous location.

Class II locations. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following:

(a) *Class II, Division 1.* A Class II, Division 1 location is a location:

(1) In which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitible mixtures; or

(2) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protective devices, or from other causes, or

(3) In which combustible dusts of an electrically conductive nature may be present.

NOTE: Combustible dusts which are electrically nonconducive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which

may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme caution is necessary to avoid ignition and explosion.

(b) *Class II, Division 2.* A Class II, Divison 2 location is a location in which:

(1) Combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitible mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus; or

(2) Dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment, and dust accumulations resulting therefrom may be ignitible by abnormal operation or failure of electrical equipment or other apparatus.

NOTE: This classification includes locations where dangerous concentrations of suspended dust would not be likely but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operating conditions or be adjacent to a Class II Division 1 location, as described above, into which an explosive or ignitible concentration of dust may be put into suspension under abnormal operating conditions.

(a) *Class III locations.* Class III locations are those that are hazardous because of the presence of easily ignitible fibers or flyings but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. Class III locations include the following:

(a) *Class III, Division 1.* A Class III, Division 1 location is a location in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured, or used.

NOTE: Easily ignitible fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, sawdust, woodchips, and other materials of similar nature.

(b) *Class III, Division 2.* A Class III, Division 2 location is a location in which easily ignitible fibers are stored or handled, except in process of manufacture.

Collector ring. A collector ring is an assembly of slip rings for transferring electrical energy from a stationary to a rotating member.

Concealed. Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them. [See "*Accessible.* (As applied to wiring methods.)"]

Conductor—(a) *Bare.* A conductor having no covering or electrical insulation whatsoever.

(b) *Covered.* A conductor encased within material of composition or thickness that is not recognized as electrical insulation.

(c) *Insulated.* A conductor encased with material of composition and thickness that is recognized as electrical insulation.

Controller. A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

Covered conductor. See "*Conductor.*"

Cutout. (Over 600 volts, nominal.) An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

Cutout box. An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper. (See "*Cabinet.*")

Damp location. See "*Location.*"

Dead front. Without live parts exposed to a person on the operating side of the equipment.

Device. A unit of an electrical system which is intended to carry but not utilize electric energy.

Disconnecting means. A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

Disconnecting (or Isolating) switch. (Over 600 volts, nominal.) A mechanical switching device used for isolating a circuit or equipment from a source of power.

Dry location. See "*Location.*"

Enclosed. Surrounded by a case, housing, fence or walls which will prevent persons from accidentally contacting energized parts.

Enclosure. The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage.

Equipment. A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like, used as a part of, or in connection with, an electrical installation.

Equipment grounding conductor. See "*Grounding conductor, equipment.*"

Explosion-proof apparatus. Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that it will not ignite a surrounding flammable atmosphere.

Exposed. (As applied to live parts.) Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (See "*Accessible.*" and "*Concealed.*")

Exposed. (As applied to wiring methods.) On or attached to the surface or behind panels designed to allow access. [See "*Accessible.* (As applied to wiring methods.)"]

Exposed. (For the purposes of § 1926.408(d), Communication systems.) Where the circuit is in such a position that in case of failure of supports or insulation, contact with another circuit may result.

Externally operable. Capable of being operated without exposing the operator to contact with live parts.

Feeder. All circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the final branch-circuit overcurrent device.

Festoon lighting. A string of outdoor lights suspended between two points more than 15 feet (4.57 m) apart.

Fitting. An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

Fuse. (Over 600 volts, nominal.) An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it. A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Ground. A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Grounded. Connected to earth or to some conducting body that serves in place of the earth.

Grounded, effectively. (Over 600 volts, nominal.) Permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient ampacity that ground fault current which may occur cannot build up to voltages dangerous to personnel.

Grounded conductor. A system or circuit conductor that is intentionally grounded.

Grounding conductor. A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding conductor, equipment. The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately derived system.

Grounding electrode conductor. The conductor used to connect the grounding electrode to the equipment ground-

ing conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system.

Ground-fault circuit interrupter. A device for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

Guarded. Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach to a point of danger or contact by persons or objects.

Hoistway. Any shaftway, hatchway, well hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

Identified (conductors or terminals). Identified, as used in reference to a conductor or its terminal, means that such conductor or terminal can be recognized as grounded.

Identified (for the use). Recognized as suitable for the specific purpose, function, use, environment, application, etc. where described as a requirement in this standard. Suitability of equipment for a specific purpose, environment, or application is determined by a qualified testing laboratory where such identification includes labeling or listing.

Insulated conductor. See *"Conductor."*

Interrupter switch. (Over 600 volts, nominal.) A switch capable of making, carrying, and interrupting specified currents.

Intrinsically safe equipment and associated wiring. Equipment and associated wiring in which any spark or thermal effect, produced either normally or in specified fault conditions, is incapable, under certain prescribed test conditions, of causing ignition of a mixture of flammable or combustible material in air in its most easily ignitible concentration.

Isolated. Not readily accessible to persons unless special means for access are used.

Isolated power system. A system comprising an isolating transformer or its equivalent, a line isolation monitor, and its ungrounded circuit conductors.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark or a qualified testing laboratory which indicates compliance with appropriate standards or performance in a specified manner.

Lighting outlet. An outlet intended for the direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder.

Listed. Equipment or materials included in a list published by a qualified testing laboratory whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

Location—(a) *Damp location.* Partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements.

(b) *Dry location.* A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

(c) *Wet location.* Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as locations exposed to weather and unprotected.

Mobile X-ray. X-ray equipment mounted on a permanent base with wheels and/or casters for moving while completely assembled.

Motor control center. An assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

Outlet. A point on the wiring system at which current is taken to supply utilization equipment.

Overcurrent. Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload (see definition), short circuit, or ground fault. A current in excess of rating may be accommodated

by certain equipment and conductors for a given set of conditions. Hence the rules for overcurrent protection are specific for particular situations.

Overload. Operation of equipment in excess of normal, full load rating, or of a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. (See *"Overcurrent."*)

Panelboard. A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (See *"Switchboard."*)

Portable X-ray. X-ray equipment designed to be hand-carried.

Power fuse. (Over 600 volts, nominal.) See *"Fuse."*

Power outlet. An enclosed assembly which may include receptacles, circuit breakers, fuseholders, fused switches, buses and watt-hour meter mounting means; intended to serve as a means for distributing power required to operate mobile or temporarily installed equipment.

Premises wiring system. That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed, which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

Qualified person. One familiar with the construction and operation of the equipment and the hazards involved.

Qualified testing laboratory. A properly equipped and staffed testing laboratory which has capabilities for and which provides the following services:

(a) Experimental testing for safety of specified items of equipment and materials referred to in this standard to determine compliance with appropriate test standards or performance in a specified manner;

(b) Inspecting the run of such items of equipment and materials at factories for product evaluation to assure compliance with the test standards;

(c) Service-value determinations through field inspections to monitor the proper use of labels on products and with authority for recall of the label in the event a hazardous product is installed;

(d) Employing a controlled procedure for identifying the listed and/or labeled equipment or materials tested; and

(e) Rendering creditable reports or findings that are objective and without bias of the tests and test methods employed.

Raceway. A channel designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this subpart. Raceways may be of metal or insulating material, and the term includes rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquid tight flexible metal conduit, flexible metallic tubing, flexible metal conduit, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

Readily accessible. Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See *"Accessible."*)

Receptacle. A receptacle is a contact device installed at the outlet for the connection of a single attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is a single device containing two or more receptacles.

Receptacle outlet. An outlet where one or more receptacles are installed.

Remote-control circuit. Any electric circuit that controls any other circuit through a relay or an equivalent device.

Sealable equipment. Equipment en-

closed in a case or cabinet that is provided with a means of sealing or locking so that live parts cannot be made accessible without opening the enclosure. The equipment may or may not be operable without opening the enclosure.

Separately derived system. A premises wiring system whose power is derived from generator, transformer, or converter windings and has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system.

Service. The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

Service conductors. The supply conductors that extend from the street main or from transformers to the service equipment of the premises supplied.

Service drop. The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.

Service-entrance conductors, overhead system. The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

Service-entrance conductors, underground system. The service conductors between the terminals of the service equipment and the point of connection to the service lateral. Where service equipment is located outside the building walls, there may be no service-entrance conductors, or they may be entirely outside the building.

Service equipment. The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

Service raceway. The raceway that encloses the service-entrance conductors.

Signaling circuit. Any electric circuit that energizes signaling equipment.

Switchboard. A large single panel, frame, or assembly of panels which have switches, buses, instruments, overcurrent and other protective devices mounted on the face or back or both. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. (See "*Panelboard.*")

Switches—(a) *General-use switch.* A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.

(b) *General-use snap switch.* A form of general-use switch so constructed that it can be installed in flush device boxes or on outlet box covers, or otherwise used in conjunction with wiring systems recognized by this subpart.

(c) *Isolating switch.* A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.

(d) *Motor-circuit switch.* A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

Switching devices. (Over 600 volts, nominal.) Devices designed to close and/or open one or more electric circuits. Included in this category are circuit breakers, cutouts, disconnecting (or isolating) switches, disconnecting means, and interrupter switches.

Transportable X-ray. X-ray equipment installed in a vehicle or that may readily be disassembled for transport in a vehicle.

Utilization equipment. Utilization equipment means equipment which utilizes electric energy for mechanical, chemical, heating, lighting, or similar useful purpose.

Utilization system. A utilization system is a system which provides electric power and light for employee workplaces, and includes the premises wiring system and utilization equipment.

Ventilated. Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors.

Volatile flammable liquid. A flammable liquid having a flash point below 38 degrees C (100 degrees F) or whose temperature is above its flash point, or a Class II combustible liquid having a vapor pressure not exceeding 40 psia (276 kPa) at 38° C (100° F) whose temperature is above its flash point.

Voltage. (Of a circuit.) The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

Voltage, nominal. A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 480Y/277, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Voltage to ground. For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

Watertight. So constructed that moisture will not enter the enclosure.

Weatherproof. So constructed or protected that exposure to the weather will not interfere with successful operation. Rainproof, raintight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.

Wet location. See *"Location."*

Subpart L—Ladders and Scaffolding

§ 1926.450 Ladders.

(a) *General requirements.* (1) Except where either permanent or temporary stairways or suitable ramps or runways are provided, ladders described in this subpart shall be used to give safe access to all elevations.

(2) The use of ladders with broken or missing rungs or steps, broken or split side rails, or other faulty or defective construction is prohibited. When ladders with such defects are discovered, they shall be immediately withdrawn from service. Inspection of metal ladders shall include checking for corrosion of interiors of open end hollow rungs.

(3) Manufactured portable wood ladders provided by the employer shall be in accordance with the provisions of the American National Standards Institute, A 14.1-1968, Safety Code for Portable Wood Ladders.

(4) Portable metal ladders shall be of strength equivalent to that of wood ladders. Manufactured portable metal ladders provided by the employer shall be in accordance with the provisions of the American National Standards Institute, A 14.2-1956, Safety Code for Portable Metal Ladders.

(5) Fixed ladders shall be in accordance with the provisions of the American National Standards Institute, A 14.3-1956, Safety Code for Fixed Ladders.

(6) Portable ladder feet shall be placed on a substantial base, and the area around the top and bottom of the ladder shall be kept clear.

(7) Portable ladders shall be used at such a pitch that the horizontal distance from the top support to the foot of the ladder is about one-quarter of the working length of the ladder (the length along the ladder between the foot and the top support). Ladders shall not be used in a horizontal position as platforms, runways, or scaffolds.

(8) Ladders shall not be placed in passageways, doorways, driveways, or any location where they may be displaced by activities being conducted on any other work, unless protected by barricades or guards.

(9) The side rails shall extend not less than 36 inches above the landing. When this is not practical, grab rails, which provide a secure grip for an employee moving to or from the point of access, shall be installed.

(10) Portable ladders in use shall be tied, blocked, or otherwise secured to prevent their being displaced.

(11) Portable metal ladders shall not be used for electrical work or where they may contact electrical conductors.

(b) *Job-made ladders.* (1) Job-made ladders shall be constructed for intended use. If a ladder is to provide

Appendix F
OSP Example

LAWRENCE LIVERMORE NATIONAL LABORATORY

Operational Safety Procedure
No. 0.121

Revised: 3-14-93
Expires: 3-14-94
Review Level: A

TITLE: LIVERMORE GROUND WATER INVESTIGATION

REASON FOR ISSUE: An Operational Safety Procedure is required for all off-site operations where the Laboratory has primary management responsibility.

RESPONSIBILITIES: R. C. Ragaini, Environmental Protection Department Head, and his Associate F. Hoffman (Alternate) are responsible for implementing the controls contained in this safety procedure and in other applicable Laboratory safety standards and for the safety of this operation.

LOCATION: Drilling and sampling operations may be conducted in the Livermore Valley and areas surrounding Site 300.

WORK TO BE DONE:

1. Aquifer mapping and sampling.
2. Well drilling and emplacement of drilling and pumping equipment.
3. Sample collection.

HAZARDS ANALYSIS:

The sources of possible personnel injury or property damage associated with the operations are:

1. Drilling Operations

   Personnel working in and near drilling rigs and platforms where hazards include moving machinery, high pressure, flammable and/or combustible fluids, scaffolding, cranes, falling objects, drilling through underground utilities, flying machinery parts, overhead power lines, and unsafe footing.

2. Electrical Hazards

   Electric power is supplied by gasoline or diesel engine generators. Working conditions may be wet and electrical shock possible.

3. Material Handling

   Lifting of heavy and bulky equipment and boxes on and off truck at emplacement locations is required.

OPERATING AND PERSONNEL CONTROLS: To effectively control the above hazards and to minimize the possibility of personnel injury or property damage, these requirements shall be followed:

1. The Underground Services Alert (U.S.A.), City of Livermore, land owners, and Zone 7 Water Board will be notified seven (7) days prior to commencement of drilling. After clearance by these notified agencies as to location of buried utilities, the LLNL Field Supervisor will mark location of new monitoring well.

2. The LLNL Health & Safety Manual will be made available to all personnel involved in the field operations. They will be required to be familiar with portions of the manual applicable to the particular operation.

3. The contractor is responsible for providing first aid and medical assistance to his employees if they are injured or become ill. Emergency telephone numbers for Medical Assistance and Fire Department shall be posted at each work site and shall be site specific; i.e., 911 for Livermore City areas, ext. 3-5333 for Site 300, and ext. 2-7333 for LLNL main site proper and other LLNL/DOE property. All injuries and accidents will be reported promptly to the Field Supervisor. Hazards Control will also be notified as soon as possible.

4. Before any operations on a facility controlled by another organization, the Field Supervisor shall contact the host Facility Safety Officer to determine site safety regulations, and to resolve any discrepancy between those regulations and this OSP.

5. In any field operation, the Field Supervisor will be responsible for safe working conditions, will halt work if site conditions are not deemed safe, and will not resume work until the unsafe conditions have been corrected. An LLNL employee who is the only LLNL employee working among the personnel shall act as Field Supervisor for LLNL participation in the work.

6. Clothing and equipment suitable for unusual work conditions will be made available and utilized as needed. Wearing of hard hats, safety glasses, and safety shoes will be required on all drilling operations.

7. Safety belts and lanyards will be worn whenever it is necessary to climb up on the aerial platform.

8. Each operation will be conducted in accordance with the Laboratory's "Working Alone" policy as defined in the LLNL Health & Safety Manual, Section 26.15. In the event that it is necessary for individuals to work alone under any circumstance, the Field Supervisor will ensure that, at a minimum, adequate communications are maintained and that other persons are aware of the itinerary, intended work locations, and estimated return time of the persons working alone.

9. All electrical systems shall be checked for grounding continuity and for compliance with the National Electrical Code during initial installation and periodically during operation.

10. Any equipment or materials left in the field unattended must be turned off, secured, and barricaded.

11. Open trenches or excavations must have barricades to provide protection for pedestrians, bicyclists, and motor vehicles. Each barricade that will be in place during darkness must be equipped with a yellow flasher.

12. All hoses operating under pressure will be securely tethered.

13. If any operation requires entry onto private property, the Field Supervisor will ensure that appropriate permission has been received in advance for entry onto the property and receive assurance from the property owner or manager that all persons associated with the property are aware of the LLNL operation.

14. The Hazards Control Safety Team Leader shall be notified prior to drilling in any new location.

This Operational Safety Procedure was reviewed by:

R. C. Ragaini	Environmental Protection Department Head
F. Hoffman	Environmental Restoration Division Leader
T. R. Crites	Hazards Control Department Head
I. M. Meisel	Hazards Control Acting Safety Team Leader
E. C. Draney	Site 300 Resident Manager
E. M. Fawcett	Hazards Control Safety Team 5 Leader

LIVERMORE SITE 200 AND SITE 300 OFF-SITE GROUND WATER INVESTIGATION ACTIVITIES

1.0 Reason For Issue

1.1 An Operational Safety Procedure is required for all off-site operations where the Laboratory has primary management responsibility. Carcinogens and other hazardous substances (e.g. benzene, chlorinated hydrocarbons, radionuclides, metals) may be encountered during drilling operations. This OSP also serves as an administrative tool to summarize many of the requirements of the *Health and Safety Manual* which are pertinent to this operation. This OSP supplements the existing Site 200 and Site 300 Site Safety Plans which address this work (UCRL- 21174 and UCRL-21172).

2.0 Work To Be Done And Location Of The Activity

2.1 Aquifer mapping and sampling.

2.2 Drilling and construction of monitor wells, extraction wells, piezometers and the installation of associated pumping equipment.

2.3 Soil, rock, and ground water sample collection.

2.4 Geophysical measurements at surface.

2.5 Location: Off-site in the Livermore Valley and areas surrounding Site 300.

3.0 Responsibilities

3.1 R. Bainer, Site 200 (Ext. 2-4635), and M. Taffet Site 300 (Ext. 2-6114) are responsible for the safety of this operation and for assuring that all work is performed in conformance with this OSP, the FSP at Site 300, and applicable sections in the *Health & Safety Manual* and *Environmental Protection Handbook*. In their absence, J. Duarte, Site 200 (Ext. 3-2638) and J. Greci, Site 300 (Ext. 3-5043) shall assume these responsibilities.

3.2 Others involved in this operation include W. McConachie, Environmental Protection Department, (Ext. 3-3501); Environmental Restoration Division Leader; I. Ziagos, Site 200 Restoration Section Leader, (Ext. 2-5479); A. Lamarre, Site 300 Restoration Section Leader, Ext. (2-0757).

3.3 Any changes in operations that improve or do not significantly affect safety and environmental controls may be approved by the Authorizing Individual for this OSP and the ES&H Team Leader. The Responsible Individual will ensure that this action is documented in a memorandum. Any changes in operations that increase the hazard level, introduce additional hazards, or decrease safety shall not be made until a revision of or supplement to this OSP has been reviewed and approved consistent with the review and approval process for the original OSP.

3.4 Before starting operation, the responsible individual shall verify and document that the operating personnel have read and understand the OSP and applicable sections of the FSP at Site 300.

4.0 Hazards Analysis

4.1 Drilling Operations

Personnel working in and near drilling rigs are exposed to a variety of mechanical hazards including moving machinery, high pressure (e.g. hydraulic lines), flammable and/or combustible fluids (gasoline in ground water), unsafe use of cranes, falling objects, drilling through underground utilities, flying machinery parts, and unsafe walking and working surfaces. The consequences of accidents involving these physical hazards can range from minor injury to fatal injury.

4.2. Electrical Hazards

Electric power is often supplied by gasoline or diesel engine generators. Working conditions may be wet and electrical shock with possible fatal consequences may occur. (In addition, it is possible that drilling operations may encounter buried electrical utilities, potentially resulting in exposure to very high voltages which could be fatal and/or initiate fires.)

4.3 Underground Utilities

Drilling operations may encounter buried utilities including gas and electrical lines. Drilling into electrical lines may potentially result in exposure to very high voltages that could be fatal and/or initiate fires. Drilling into gas lines may potentially result in an explosion.

4.4 Material Handling

Lifting of heavy and bulky equipment and boxes on and off trucks at emplacement locations is required. Physical injury, particularly back strain or crushing injuries, may occur.

4.5 Contaminated Materials

Drillers, geologists, samplers and support personnel may come in contact with sediments, rock, soil, ground water and drilling fluids which have been contaminated with varying concentrations of hazardous materials. The benzene component of gasoline, some halogenated solvents, some metals, and the radionuclides which may be encountered may be carcinogenic or hazardous; repeated exposure to these materials by inhalation, ingestion, or skin absorption may increase the risk of developing cancer or other ailments. In addition, overexposure to halogenated solvents may result in central nervous system damage, liver damage, as well as adverse reproductive genetic effects. Skin contact with halogenated solvents can also de-fat the skin, resulting in localized irritation, skin cracking, and infections, a condition referred to as primary dermatitis. It is anticipated that the concentration of most of these contaminants in ground water, rock, soil, drilling fluids or sediments will be so low as not to pose an occupational exposure concern. However, there may be exceptions encountered (e.g. pockets of pure gasoline floating on the water table) where exposure of the drilling crew could be significant. Where high concentrations of gasoline or other flammable material is present, the possibility of fire or explosion of vapors trapped in the borehole may exist.

4.6 Geophysical Measurements

A variety of surface geophysical measurements may be conducted using seismic and electrical tehniques. Seismic sources including vibrators, weight drops, airguns and shotgun shells, present the possibility of injury. Some seismic sources emit loud noises and can

cause hearing damage. Most electrical methods have no associated hazards, although the possibility of electrical shock may be present in some applications.

4.7 Noise

Drilling equipment is capable of producing sound levels in excess of 85 dB(A), the 8-hour Threshold Limit Value recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) and adopted by LLNL.

5.0 Controls

The hazards listed in Section 4.0 are addressed in the LLNL *Health and Safety Manual,* the Environmental Restoration Program Standard Operating Procedures, the Environmental Restoration Series Site Safety Plan and the Safety and Operations Manual for Site 300. These documents are provided to and discussed with all personnel including those involved in drilling and sampling operations before work begins so that each worker is familiar with portions of the documents pertaining to the particular operation.

The Site Safety Officer or designated person is responsible for safe working conditions and shall halt work if site conditions are deemed unsafe. Operations shall not be resumed until the conditions have been corrected. In addition, a daily safety meeting shall be conducted with the Field Geologist prior to the commencement of drilling operations to highlight specific safety concerns particular to the day's operations.

The following section lists additional safeguards to address the specific hazards described in Section 4.0.

5.1 Drilling Operations

5.1.1 All subcontractors working on and around drill rigs shall be properly trained to work on these rigs by their companies in accordance with LLNL recognized standards.

5.1.2 At a minimum, workers are required to wear level D protective clothing-which includes hard hats, gloves, safety glasses, and steel-toed shoes. The Field Geologist shall be responsible for the enforcement of personal protective clothing requirements.

Hearing protection may be required if noise is above acceptable levels as determined by Hazards Control.

5.1.3 Only trained operators shall be used for drilling operations. In addition, the safe use of drilling machinery shall be highlighted during the daily safety meeting. All hoses operating under pressure shall be securely tethered.

5.1.4 Workers required to climb drilling masts to perform maintenance and repairs are required to wear safety belts and/or lanyards. All workers required to work on the mast of the drill rig shall be properly trained in the use of safety belts and lanyards by their companies to conform with LLNL standards.

5.1.5 An exclusion zone shall be clearly marked with barricades, signs and/or taping where only trained personnel associated with the drilling operations are permitted.

5.1.6 Open boreholes and wells shall be covered and/or secured when unattended.

5.2 Electrical Hazards

All electrical systems used during drilling and sampling operations shall be checked for proper grounding during the initial installation.

5.3 Underground Utilities

The Underground Services Alert (U.S.A.), City of Livermore, land owners, and Zone 7 Water Board shall be notified seven (7) days prior to commencement of drilling off-site near Livermore. San Joaquin County Health Services, U.S.A. and landowners shall be notified prior to commencement of drilling off-site near Site 300. After clearance by these agencies as to location of buried utilities, the LLNL designated Drilling Supervisor shall approve the location of new wells to avoid any possibility of disrupting these utilities.

5.4 Material Handling

Workers are instructed in safe handling and lifting practices. If any specialized lifting equipment is to be used, only trained operators shall be authorized to use such equipment.

5.5 Contaminated Materials

The appropriate Health and Safety Technician and Environmental Analyst shall be notified prior to the commencement of any new drilling or downhole geophysical operations. Clothing and equipment, including appropriate monitoring equipment suitable for the work conditions as specified by Hazards Control, shall be used as needed. The Field Geologist shall monitor the breathing zone, drill cuttings and /or drilling mud and fluids with an Organic Vapor Meter (OVM) and/or an Organic Vapor Analyzer (OVA), and a radiation meter. If organic vapor or radiation levels exceed twice background levels, or in the absence of background concentrations, 5 ppm, when measured, using either an OVM or OVA or there is evidence of contamination that could impact worker health and safety, then the Field Geologist shall cease operations and contact the designated Drilling Supervisor who shall contact the appropriate technical support personnel from Hazards Control. If necessary, personal protective clothing shall be upgraded to prevent worker exposure.

5.6 Geophysical Measurements

If explosives are used as a seismic source, the Shot Loader and Detonator shall be fully licensed and trained as to the proper handling and initiating of the charges. Hearing protection shall be required for personnel operating seismic sources or other geophysical instruments that generate noise above acceptable levels as determined by Hazards Control.

5.7 Noise

Whenever new or previously unevaluated drilling equipment is used, the drilling geologist shall contact Hazards Control ES&H Team 4 to obtain a noise survey. If noise exposures approach or exceed 85 dB(A) hearing protection, as recommended by Hazards Control shall be worn by all employees working within the designated hazard radius.

5.8 Other Safety Documents

The LLNL *Health & Safety Manual*, the Environmental Restoration Program Standard Operating Procedures, and the Environmental Restoration Series Site Safety Plan shall be made available to all personnel involved in the field operations. They shall be required to be familiar with portions of the manual applicable to the particular

operation. A daily safety meeting with the field personnel shall be conducted by the Field Geologist prior to the commencement of drilling operations.

5.9 Before conducting any operations on a facility controlled by another organization, the Site Safety Officer or designated Drilling Supervisor shall contact the host Facility Safety Officer to determine site safety regulations, and to resolve any discrepancy between those regulations and this OSP.

5.10 In any field operation, the designated Site Safety Officer or Drilling Supervisor shall be responsible for safe working conditions, shall halt work if site conditions are not deemed safe, and shall not resume work until the unsafe conditions have been corrected. Hazards Control shall also be notified as soon as possible. The Field Geologist shall oversee and enforce all field activities.

5.11 Each operation shall be conducted in accordance with the Laboratory's "Working Alone" policy as defined in the LLNL *Health & Safety Manual*, Section 26.15. In the event that it is necessary for individuals to work alone under any circumstance, the Site Safety Officer or designated Drilling Supervisor shall ensure that, at a minimum, adequate communications are maintained and that other persons are aware of the itinerary, intended work locations and estimated return time of the persons working alone.

5.12 Any equipment or materials left in the field unattended shall be turned off, secured and barricaded prior to leaving the site.

5.13 If any operation requires entry onto private property, the Site Safety Officer or designated Drilling Supervisor shall ensure that appropriate permission has been received in advance for entry onto the property, and receive assurance from the property owner or manager that all persons associated with the property are aware of the LLNL operation.

6.0 Environmental Concerns and Controls

6.1 The primary environmental concerns are cross-contamination of water bearing zones and surface contamination from drill cuttings and/or drilling fluids.

6.1.1 During drilling operations, the drill cuttings or drilling fluids shall be monitored by the Field Geologist as outlined in Section 5.5 to ensure that no cross-contamination or surface contamination occurs.

6.2 At Site 300 disruption of habitat of two endangered species, the San Joaquin kit fox (Vulpes macrotis mutica) and the large-flowered fiddleneck (Amsinka grandiflora) could occur.

6.2.1 Sixty days prior to the commencement of drilling, a survey will be conducted to determine the presence or absence of Kit fox dens and the type. No offsite drilling or other activities shall be performed within 25 feet of a kit fox den at any time.

6.2.2 No drilling activities will be conducted which may endanger a population of large-flowered fiddleneck.

6.3 Drilling debris, decontamination materials and discarded safety equipment shall be placed in separate containers labeled "Potentially Hazardous Waste-Pending Analysis" and stored in the Environmental Restoration Division's designated Waste Accumulation Area at Building 597 or, for work at Site 300, Building 843 Waste Accumulation Area until analytical results are received. Any materials found to be contaminated shall be disposed of through Hazardous Waste Management.

6.4 Drilling mud shall be disposed of according to Environmental Protection Department's Environmental Restoration Series Standard Operating Procedures for Site 200, dated July 1990, (M-24S Rev. 1.3) and Site 300 dated August, 1992, (UCRL-MA-10911S).

6.5 No drilling operations will be conducted in identified historic or prehistoric sites at Site 300, and access through these sites will be restricted by means of stakes, flagging, barricades, etc.

7.0 Training

7.1 All authorized operators shall have completed the following safety courses if they are utilizing intrusive methods into potentially contaminated areas:

HS-0001 - New Employee Orientation.

HS-4050 - Health Hazards Communication.

EP-0006 - Hazardous Waste Handling Practices - Untrained personnel may work under the supervision of trained personnel. Employees must be trained within 6 months of hire date and annually thereafter.

HS-0095 - Health and Safety for Employees and Visitors at Site 300.

7.2 Personnel involved shall have received at a minimum the 40 hours of CERCLA/SARA Health and Safety classroom training and 24 hours of field training pursuant to the requirements of 29 CFR Section 1910.120. Supervisory personnel shall have taken an additional 8 hours of specialized supervisory training. All personnel shall have taken the annual 8 hour refresher Health and Safety training as necessary.

7.3 If noise levels are found to exceed 85 dB(A) all LLNL and supplemental labor employees working on the site shall attend HS-4360 "Noise".

7.4 The responsible individual shall ensure that all required training, including on-the-job training if applicable, is complete and documented.

8.0 Maintenance

8.1 All field monitoring equipment shall be calibrated as specified in the respective Site 200 and Site 300 Site Safety Plans, LLNL Document Numbers UCRL-21174 dated July, 1989, and UCRL-21172 dated October, 1989.

8.2 Drilling equipment shall be maintained by the drilling subcontractor.

9.0 Quality Assurance

9.1 Quality Assurance requirements are detailed both in the Quality Assurance Project Plan - LLNL Ground Water Project, UCAR # 10219 dated June, 1989, (Site 200) and in the Quality Assurance Project Plan, LLNL Site 300 Environmental Restoration Project, UCRL-AR-103160, Rev. 1 (Site 300).

10.0 Emergency Response Procedures

10.1 Contractors are responsible for providing first aid and medical assistance to their employees if they are injured or become ill. Emergency telephone numbers for Medical Assistance and Fire Department shall be posted at each work site and shall be site specific, i.e., 911 for Livermore City areas, 911 for Site 300, and 911 for LLNL main site property and other LLNL/DOE property. All injuries and accidents shall be reported promptly to the Site Safety Officer or designated Drilling Supervisor. Hazards Control will also be notified as soon as possible.

11.0 References

11.1 Site Safety Plan for Lawrence Livermore National Laboratory CERCLA Investigations UCRL-21174, July, 1989.

11.2 Site Safety Plan for Site 300 Environmental Restoration UCRL #21172, October, 1989.

11.3 Environmental Restoration Program Standard Operating Procedures, July 1990, #M-245 Rev. 1.3.

11.4 LLNL Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs) UCRL-MA-109115, April, 1992.

11.5 Quality Assurance Project Plan - LLNL Ground Water Project UCAR # 10219, June, 1989.

11.6 Quality Assurance Project Plan Lawrence Livermore National Laboratory Site 300 Environmental Restoration Project, UCRL-AR-103160, Rev. 1, October, 1992.

12.0 Review and Approval

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Appendix G
Levels Of Personal Protection**

APPENDIX G

LEVELS OF PERSONAL PROTECTION**

LEVEL A - To be selected when the greatest level of skin, respiratory, and eye protection is required.

Level A equipment; used as appropriate.

1. Pressure-demand, full face-piece self-contained breathing apparatus (SCBA), or pressure-demand supplied air respirator with escape SCBA, approved by the National Institute for Occupational Safety and Health (NIOSH).
2. Totally encapsulating chemical-protective suit.
3. Coveralls.*
4. Long underwear.*
5. Gloves, outer, chemical-resistant.
6. Gloves, inner, chemical-resistant.
7. Boots, chemical-resistant, steel toe and shank.
8. Hard hat (under suit).*
9. Disposable protective suit, gloves and boots (Depending on suit construction, may be worn over totally encapsulating suit).
10. Two-way radios (worn inside encapsulating suit).

*Optional, as applicable.

LEVEL B - The highest level of respiratory protection is necessary, but a lesser level of skin protection is needed.

Level B equipment; used as appropriate.

1. Pressure-demand, full-face piece self-contained breathing apparatus (SCBA), or pressure-demand supplied air respirator with escape SCBA (NIOSH approved).
2. Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls).
3. Coveralls.*
4. Gloves, outer, chemical-resistant.
5. Gloves, inner, chemical resistant.
6. Boots, outer, chemical-resistant steel toe and shank.
7. Boot-covers, outer, chemical resistant (disposable)*.
8. Hard hat.

9. Two-way radios (worn inside encapsulating suit).
10. Face shield.*

*Optional, as applicable.

LEVEL C- The concentrations(s) and type(s) of airborne substance(s) is known and the criteria for using air purifying respirators are met.

Level C equipment; used as appropriate.

1. Full-face or half-mask, air purifying, canister equipped respirators (NIOSH approved).
2. Hooded chemical-resistant clothing (overalls; two-piece chemical-splash suit; disposable chemical-resistant overalls).
3. Coveralls.*
4. Gloves, outer, chemical-resistant.
5. Gloves, inner, chemical resistant.
6. Boots, outer, chemical-resistant steel toe and shank.*
7. Boot-covers, outer, chemical resistant (disposable).*
8. Hard hat.
9. Escape mask.*
10. Two-way radios (worn under outside protective clothing).
11. Face shield.*

*Optional, as applicable.

LEVEL D - A work uniform affording minimal protection: used for nuisance contamination only.

1. Coveralls.
2. Gloves.*
3. Boots/shoes, chemical-resistant steel toe and shank.
4. Boots, outer, chemical-resistant (disposable).*
5. Safety glasses or chemical splash goggles.*
6. Hard hat.
7. Escape mask.*
8. Face shield.*

*Optional as applicable.

The types of hazards for which levels A, B, C, and D protection are appropriate are described below:

Level A protection should be used when:

1. The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either the measured (or potential for) high concentration of atmospheric vapors, gases, or particulates; or the site operations and work functions involve a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the intact skin,
2. Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible, or
3. Operations must be conducted in confined, poorly ventilated areas and the absence of conditions requiring Level A have not yet been determined.

Level B protection should be used when:

1. The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection.

   NOTE: This involves atmospheres with IDLH concentrations of specific substances that do not represent a severe skin hazard; or that do not meet the criteria for use of air-purifying respirators.
2. The atmosphere contains less than 19.5 percent oxygen, or
3. The presence of incompletely identified vapors or gases is indicated by a direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin.

Level C protection should be used when:

1. The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through any exposed skin,
2. The types of air contaminants have been identified, concentrations measured, and a canister respirator is available that can remove the contaminants, and
3. All criteria for the use of air-purifying respirators are met.

Level D protection should be used when:

1. The atmosphere contains no hazard, and
2. Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

   NOTE: As stated before combinations of personal protective equipment other than those described for Levels A, B, C, and D protection may be more appropriate and may be used to provide the proper level of protection.

**This information is from 29 CFR 1910.120 Appendix B.

END

DATE FILMED

11/15/93