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465759

SITE SAFETY PLAN

PRE-DESIGN SITE INVESTIGATION
AMERICAN CHEMICAL SERVICE, INC.

GRIFFITH, INDIANA

JANUARY 1996

PREPARED FOR:
ACS RD/RA EXECUTIVE COMMITTEE
GRIFFITH, INDIANA

• • •

PREPARED BY:
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January 5, 1996 Reference No. 3481

Ms. Sheri Bianchin
UNITED STATES ENVIRONMENTAL
PROTECTION AGENCY (USEPA)
Region V (HSRL-6J)
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Dear Ms. Bianchin:

Re: Site Safety Plan - ACS

Please find enclosed copies of the Site Safety plan which has been revised to address your comments from December 1995.

If you have any questions, please call.

Sincerely,

CONESTOGA-ROVERS & ASSOCIATES

Ronald Frehner

RF/br
c.c. Holly Grejda; IDEM
Rob Lance; Black & Veatch
ACS Technical Committee (w/o Enc.)

RESPONSE TO U.S. EPA AND IDEM COMMENTS DATED DECEMBER 26, 1995 REVISED SITE SAFETY PLAN FOR THE PRE-DESIGN SITE INVESTIGATION

The U.S. EPA and IDEM comments (i.e., Agnecy Comments) on the Revised Site Safety Plan For The Pre-Design Site Investigation, American Chemical Services, Inc. Superfund Site, Griffith, Indiana, dated December 26, 1995, are provided below and are followed by a response to each agency comment prepared by Montgomery Watson on behalf of the ACS NPL Site RD/RA Executive Committee (i.e., PRP Response).

Agency Comment

1. Please provide a cover sheet for Site Safety Plan, Appendices J-L which does not state "Client Review Draft."

PRP Response

The cover sheet for Appendicies J-L (now J-O) have been revised.

Agency Comment

2. The SSP should acknowledge that use of heavy equipment presents its own inherent hazards and observers and non-essential personnel should remain a safe distance from these operations.

PRP Response

Language has been added to page 4-2, last sentence under "HEAVY EQUIPMENT".

Agency Comment

3. The SSP discussed the use of remote drum openers, non-sparking tools, etc. The regulation found at 29 CFR 1910.120(j) (5) (ii) requires material handing equipment to be provided with explosive containment devices or protective shields to protect operators from exploding containers. The SSP did not discuss if any such devices will be used at the site. If so, then above-cited regulation should be complied with.

PRP Response

Regulations found at 29 CFR 1910.120(j) (5) (ii) are now discussed under Appendix O, which is referenced on page 5-10 under Drum Consolidation/Waste Sampling - Special Work Practices.

Agency Comment

4. The Emergency Procedures section of the SSP should address "critique of response and follow-up" to site emergencies, in accordance with 29 CFR 1910.120 (p) (8) (ii) (J).

PRP Response
29 CFR 1910.120 (p) applies to RCRA response to emergencies; therefore it does not apply to activities being performed at the site. It is not the intention of this program to include professional emergency response activities as part of the field operations. Thus, all site personnel are instructed to assess emergencies in terms of whether the problem can be solved safely with the personnel and equipment at the site, or not. If it is determined that site personnel are able to contain the emergency safely, they are instructed to do so. If it is determined that the emergency is out of the realm of abilities for existing site personnel, evacuation and notification takes place immediately. These actions are discussed in Appendix H, which is referenced on page 7-2 under On-Site Communication System.

Agency Comment
5. The SSP should acknowledge that OSHA Construction Standards found in 29 CFR 1929 Subpart P will be complied with if excavations are made at the site.

PRP Response
Excavations will only be performed during pilot/treatability testing activities. The SSP will be amended with the 50% and Final Design deliverables. If open excavations are encountered during other activities, personnel will refrain from entering them, as discussed an page 4-3, under "EXCAVATIONS".

Agency Comment
6. Use of MSDSs is an acceptable means to convey chemical hazards to site personnel. However, many of the MSDS sheets in Appendix B are quite outdated, and several of the TLVs listed are not current. The PELs/TLVs should be reviewed and made current.

PRP Response
Montgomery Watson has reviewed the MSDSs and is in the process of obtaining updated information for chemicals or compounds that had MSDSs prepared prior to 1990. The following MSDSs are being evaluated for updated information:

chromic acid and chromates
thallium metal
chromium metal/powder
manganese metal/powder
potassium metal
sodium metal
ethyl bromide
isohexanes
di(2-ethylhexyl)phthalate
benzoic acid
dimethyl phthalate
n-butyl alcohol
o-dichlorobenzene
acetone solvent blend
cobalt metal/powder
selenium
magnesium metal
zinc metal/powder
calcium metal
cumene
phthalic anhydride
carbon tetrachloride
dibutyl phthalate
diethyl phthalate
isophorone
oleic acid

naphthalene
hexachloroethane
bromoformbenzaldehyde
1,1,2-trichloroethane
p-nitroaniline
mesitylene
1,1,2,2-tetrachloroethane

Because of the time involved with searching manufacturer and supplier "product information" for MSDSs with more current information than that already provided, Montgomery Watson will need more time to gather and evaluate data. Montgomery Watson will provide updated MSDS information prior to the initiation of field work.

Agency Comment

7. The SSP should contain a Hazard Communication Plan for the site; the SSP should be written in accordance with 29 CFR 1910.1200. Material safety data sheets must be available for all chemicals brought on site such as decontamination chemicals, gasoline and other fuels, equipment calibration gasses, etc.

PRP Response

Acknowledgment of Hazard Communication Training has been included at the bottom of page 1-3 and the top of page 1-4, under "EMPLOYEE EDUCATION AND TRAINING". A site Hazard Communication Plan has been added to the SSP as Appendix M.

Agency Comment

8. The SSP should contain a written respiratory protection program for the selection, use, and maintenance of the respirators which will be used at the site. The *written* program must be in accordance with 29 CFR 1910.134.

PRP Response

A written respiratory protection program has been included as Appendix N, and referenced on page 5-8 in the first paragraph.

Agency Comment

9. The SSP designates employees will be responsible for providing first aid to injured site personnel, hence, the regulation found at 29 CFR 1910.1030 -- Occupational Exposure to Bloodborne Pathogens is applicable. Employees who are designated as responsible for rendering first aid or medical assistance as part of their job duties are to be covered by this standard. It excludes employees who perform unanticipated "Good Samaritan" acts since such an action does not constitute "occupational exposure." If an employee is trained in first aid and designated by the employer as responsible for rendering medical assistance as part of his/her job duties, that employee is covered by all requirements of the standard, including Hepatitis B vaccination, post exposure incident follow-up, training, and personal protective equipment.

PRP Response

A discussion of the bloodborne pathogens standard has been added to page 7-4 under "First Aid" as the last 3 paragraphs in that section.

CCH/dlp/PJV
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SITE SAFETY PLAN

PRE-DESIGN SITE INVESTIGATION
AMERICAN CHEMICAL SERVICE, INC.

GRIFFITH, INDIANA

JANUARY 1996

Beth Darnell
Health and Safety Coordinator

Peter J. Vagt
Project Manager

SITE SAFETY PLAN (SSP)

KEY PERSONNEL

Site Manager: David Pieczynski
Alternate: Philip Smith

Site Safety Officer: David Pieczynski
Alternate: Philip Smith

PROPOSED PROJECT START DATE
January 1996

This Site Safety Plan does not supersede or in any way relieve subcontractors of their obligations under any applicable OSHA regulations including 29 CFR 1910: Occupational Safety and Health Standards and 29 CFR 1926: Health and Safety Regulations for Construction.

Montgomery Watson personnel working at this site meet the training and medical monitoring requirements of 29 CFR 1910.120: Hazardous Waste Operations and Emergency Response. Documentation of this training and medical surveillance can be obtained upon written request to Montgomery Watson, Corporate Health and Safety Manager.

The health and safety procedures set forth in this Site Safety Plan (SSP) are based on the site conditions and chemical hazards known or expected to be present using site data available at the time this SSP was written. This SSP is intended solely for the use of Montgomery Watson personnel during the activities described in this SSP. This SSP is subject to review and revision by Montgomery Watson's Corporate Health and Safety Manager (HSM) or designated alternate when it is deemed necessary by actual Site conditions encountered during the field activities.

INTRODUCTION

This Site Safety Plan provides guidelines and procedures necessary to protect the health and safety of Montgomery Watson personnel during field activities. Tasks to be completed include:

- Monitoring well installation
- Soil sampling
- Groundwater elevation measurement
- Groundwater sampling
- Geoprobe sampling
- Surface water sampling
- Sediment sampling
- Waste sampling
- Elevation and location survey
- Soil borings
- Drum Consolidation

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KEY PERSONNEL, RESPONSIBILITIES AND TRAINING

GENERAL

Training of Site personnel will conform with pertinent OSHA regulations including 29 CFR 1910.120. There will be a pre-project Safety Meeting, during which Site personnel will be supplied with a copy of the Health and Safety Plan. The Site Safety Officer (SSO) will discuss Site operations, and workers will be instructed in the recognition, avoidance and prevention of unsafe activities and conditions. Emergency practices and procedures will be reviewed.

The SSO has the authority and responsibility to change levels of protection in accordance with the guidelines of this document. In addition, the SSO and Health and Safety Manager (HSM) have authority to shutdown the operations should conditions warrant such action.

PERSONNEL ROLES

Project Manager (PM)
The PM Peter J. Vagt will be responsible for general oversight of project activities including the health and safety plan, providing for on-site inspection of plan compliance, and assigning a Site Safety Officer. He will also interface with the agency Project Coordinators.

Health and Safety Manager (HSM)
The HSM Beth Darnell is responsible for maintaining proper medical surveillance (including pre-entry and exit examinations, if required), providing hazard communication information, training employees in safe operating procedures, and advising the PM on any matters concerning the health and safety of employees or the public. The HSM may be required to perform various types of area or personnel monitoring for purposes of determining worker exposure and proper selection of personal protective equipment if unforeseen chemical hazards are encountered. The HSM should be consulted when any changes in the

recommended procedures or levels of protective equipment are made.

Site Safety Officer (SSO)
The Site Safety Officer David Pieczynski is responsible for field implementation of this SSP and enforcement of safety rules and regulations. The SSO will handle liaison with subcontractors on matters relating to health and safety. Other site-specific SSO functions include:

- Verify that utility clearance has been performed.
- Inform local fire and police department of site activities
- Inform the hospital of the potential of contaminated victims
- Oversee day-to-day implementation of the SSP by subcontractor employees.
- Interact with subcontractor project personnel on health and safety matters.
- Determine levels of protection.
- Provide "refresher" training to new Montgomery Watson and subcontractor site personnel on health and safety matters.
- Verify that Montgomery Watson and subcontractor site personnel have received proper training and participate in a medical surveillance program.
- Inspect and maintain (daily) safety equipment which includes calibration of air monitoring instrumentation.
- Perform or direct ambient air quality monitoring as warranted.
- Modify SSP as needed and notify appropriate persons of changes.
- Investigate and report on-site accidents/incidents.
- If Montgomery Watson employees enter excavations, act as the competent person and ensure OSHA excavation requirements are enacted.
- Verify that Montgomery Watson and subcontractor site personnel are familiar with the hospital route, and that the route map is posted in the work trailer or site vehicles.
- Establish detailed procedures and routes for evacuation from the site.

- Establish the Exclusion, Decontamination and Support Zones at the site, as necessary, and provide means of securing the work area.

- Implement and direct confined space entry procedures if under the scope of work.

The SSO will hold initial startup and daily safety briefings with Montgomery Watson staff and subcontractors. Daily checklists will be maintained, and kept in the field (i.e., on-site) during site operations. Once site activities (or a phase of work) is complete, the checklists will be logged and filed with Consultant's Secured Files. It is not anticipated that these forms will be submitted to the Agencies, but these documents will be made available as required by the UAO. The SSO will use the comprehensive and daily checklists found in Appendix A when conducting the briefings.

The SSO will report accidents such as injury, overexposure, or property damage to the HSM, and will consult with the HSM on specific health and safety issues arising over the course of the project.

EMPLOYEE EDUCATION AND TRAINING

Personnel activity involved in site activities must participate in routine health and safety education and training programs. These programs directed by the HSM are designed to provide employees with a thorough knowledge of hazardous materials, health and safety hazard potentials and compliance with federal OSHA 29 CFR 1910.120(e): 40-hours initial off site instruction, 24-hours on site supervised work, 8 hours annual review course, supervisor's additional 8-hours specialized training, and U.S. EPA requirements. Verification of employee training will be maintained in the field files during site operations and returned to the office files each time field operations cease. The Health and Safety Training includes the following:

- General Safety Rules
- Basics of Chemistry
- Basics of Toxicology/Physiology
- Hazardous Materials (types/characteristics)
- Hazard Communication Information
- Respiratory Protection
- Respirator Training
- Chemical Protective Clothing
- Decontamination Procedures/Personal Hygiene
- Confined Space Work/Safety
- Atmospheric Testing/Sampling Procedures
- Emergency Response Procedures

Montgomery Watson personnel have been trained under the Hazard

Communication Standard (Appendix M). The Montgomery Watson SSO will have received additional training related to specific responsibilities. This will include instruction (formal and informal) in the use of air monitoring equipment to be utilized on-site. In addition, the SSO will be certified and current in Red Cross first-aid and cardio-pulmonary resuscitation (CPR).

Health and Safety Plan Training

An on-site "start-up" health and safety meeting and daily morning safety briefings will be held by the Montgomery Watson SSO. These meetings will include a discussion of the health and safety considerations for Site activities, and necessary protective equipment. Emergency procedures will be reviewed with Site personnel. The use, limitations, and inspection of air-purifying respirators will be discussed and proper personal and equipment decontamination procedures and protocols reviewed.

MEDICAL SURVEILLANCE PROGRAM

Employees involved with this project work will participate in a medical surveillance program under the direction of an Occupational Physician. This program includes baseline, annual or bi-annual, and exit examinations. The typical annual or bi-annual physical examination protocol includes:

- Comprehensive Health and Exposure History
- Physical and Neurological Evaluation
- Chest X-ray
- Electrocardiogram
- Urinalysis
- Stool Occult Blood
- Blood Chemistry Profile
- Hematology Profile
- Pulmonary Function Testing
- Audiometry
- Vision Testing
- Blood Lead Level
- Lyme Disease

In addition, if there is evidence of exceptional occupational exposure, optional medical testing for heavy metals, RCB cholinesterase, serum PCB level, and reticulocyte count is performed with approval of the HSM.

Additionally, employees are evaluated to determine if they are physically able to perform work while using respiratory protective equipment, in compliance with 29 CFR Part 1910.

The medical history records for Montgomery Watson personnel will be maintained with Montgomery Watson's medical monitoring physicians.

2

SITE DESCRIPTION/HAZARD SUMMARY

SITE OVERVIEW

The ACS site is located at 420 South Colfax Avenue in Griffith, Indiana. The site is bordered on the east and northeast by Colfax Avenue. The Chesaapeake and Ohio railway bisects the site in a northwest-southeast direction, between the fenced On-Site area (north) and the Off-Site Area (south). On the west and northwest, south of the Chesapeake and Ohio railway, the site is bordered by the abandoned Erie and Lackawanna railway, and the active portion of the Griffith Municipal Landfill. North of the Chesapeake and Ohio railway, the site is bordered on the west by wetland areas. The northern boundary of the site is formed by the Grand Trunk railway. (Figure 2) There are five land disposal areas at the ACS site: On-Site Containment Area, Still Bottoms Area, Treatment Lagoons, Off-Site Containment Area and Kapica/Pazmey Area. The Griffith Municipal Landfill is located within the boundaries of the site, however, it is not a part of the Remedy at the site. The Griffith Municipal Landfill is an active solid waste disposal facility and has operated since the 1950s.

Based on information provided by American Chemical Service, Inc., the ACS facility began operation in May, 1955 as a solvent recovery facility. Solvent recovery remained the primary operation performed on-site though in the late 1960s, which the manufacture of small quantities of specialty chemicals began. These manufacturing operations included treating rope with fungicide, bromination and treating ski cable.

In 1961, ACS sold a two-acre parcel to John Kapica, and in 1962 Kapica began the operation of his drum reclaiming business at the location. Operations at Kapica Drum, Inc. consisted of drum reconditioning. Kapica Drum was sold to Pazmey Corporation in February 1980. Kapica/Pazmey operated from 1980 to 1987. The Pazmey Corporation was sold to Darija Djurovic in March 1987.

ACS' solvent operations involved spent solvent mixtures containing alcohols, ketones, esters, chlorinated solvents, aromatics, aliphatics, and glycols. In the

early years of operation, spent solvents were stored in 55-gallon drums at various locations at the Site. Solvent recovery was performed in batch evaporation units, which were charged by pumping material directly from 55-gallon drums into the evaporation vessels. Still bottoms from the evaporation vessels were disposed in the Still Bottom Pond, prior to the installation of incinerators at the facility. ACS installed its first incinerator in 1966 and installed a second incinerator in 1969. The incinerators were used to burn still bottoms and non-reclaimable materials generated at the site, and wastes from off-site. The incinerator units were dismantled in 1977.

From 1970 to 1975, the spent solvents reclaimed at the Site were similar to those which were handled in the 1960s. However, an increasing percentage of shipments were received at the Site in bulk tanker trucks. In addition, the batch manufacturing processes were expanded during this period. A lard oil process which utilized tallow and animal rendering was used to manufacture a lubricant product. This process, along with a soldering flux operation, were discontinued prior to 1990. In 1971, the additive manufacturing area was built. Various detergents, lubricants, and chemical additives were manufactured, in addition to soldering flux, various amines, methanol, formaldehyde, sodium hydroxide, and maleic anhydride. An epoxidation plant was constructed in 1974 and a bromination operation using hexane was added in 1975. At various times up until 1990, the epoxidation plant used toluene or benzene as a reaction carrier.

Some time between 1975 and 1990, the solvent distillation units were replaced with new units though the types of solvent wastes reclaimed remained essentially the same. Spent solvent and reclaimed solvent recovery tank farms were constructed during this time period and the majority of the spent solvent waste streams were shipped in bulk tanker trucks, although drummed wastes were still processed. A hazardous waste drum unloading dock and storage area were built in the early 1970s, with spill containment curbing and a sump area added at a later date. In September, 1990 ACS lost its Resource Conservation and Recovery Act (RCRA) interim status, and hazardous waste operations ceased. Clean closure of hazardous waste units was accepted by the Indiana Department of Environmental Management in 1992 and ACS currently operates as a chemical production facility at the Site.

SCOPE OF WORK

The Pre-Design Work Plan was prepared in response to the Unilateral Administrative (UAO) Order issued by the United States Environmental Protection Agency (U.S. EPA), Region V, on September 30, 1994, by Montgomery Watson Americas, Inc. (Montgomery Watson) on behalf of the Respondents. The purpose of the Pre-Design task is to develop additional data needed to prepare the Remedial Design for the site remedy.

The purpose of the groundwater contamination extent investigation is to determine

the current extent of groundwater contamination. The extent of groundwater contamination was previously determined during the RI through a combination of permanent (i.e., monitoring wells) and temporary water sampling points (i.e., geoprobe-type sampling points). Because of the time that has past since the RI, an additional investigation is needed to determine the current extent of groundwater contamination related to the ACS NPL site.

The purpose of the Detection/Compliance Monitoring Program is to determine if the extent of the groundwater contamination changes during the period prior to the installation of the Perimeter Groundwater Containment System. After installation of the Perimeter Groundwater Containment System, the Detection/Compliance Monitoring Program will be modified to monitor the effectiveness of the Perimeter Groundwater Containment System.

The purpose of the wetlands investigation is to provide additional delineation of potential contaminant impacts identified in the wetlands. The investigation will focus on conducting additional sampling in the vicinity of RI sampling locations west of the ACS plant and north of the On-Site Containment Area.

Tracer Investigation

The tracer investigation will focus on four areas: Wetlands, north of the Grand Trunk Railroad, vicinity of MW-7, and in the Vicinity of well MW-6. In the cases of the wetlands north of the Grand Trunk Railraod, and MW-7, the goal is to locate the edge of the plume (i.e., non-detection of VOCs) leading to the installation of a monitoring well. In the case of MW-6, the goal is to determine if contamination from the town of Griffith underground storage tank has impacted the groundwater in the vicinity of MW-6. Groundwater samples will be analyzed in the field for a target list of VOCs.

Well Installation

Based on the results of field testing, additional wells will be installed to verify the extent of groundwater contamination. Based upon the available information, three Upper Aquifer wells are proposed at this time (MW-25, MW-26, and MW-27) (Figure 3-2). During the RI, the extent of the VOC plume was determined with a similar temporary sample location technique (i.e., the Tracer Investigation). The proposed wells would be located at the limits of this previously identified VOC plume. Additional wells may be proposed based upon the above described field investigation results.

The available water level data indicates that the six residential wells nearest to the site are located upgradient of the site. To complete the detection/compliance monitoring program, three additional Lower Aquifer well (MW28, MW-29, and MW-30) are proposed (Figure 3-2). One well, MW-28, will be located to the east of Colfax Road between the site and a group of six residential wells, MW-29 will be located below the plume to monitor the vertical migration of the plume, and MW-30 will be installed downgradient of MW-9, to determine if VOCs are present in the lower aquifer.

The Upper Aquifer wells will be installed with 10-ft screens at the top of the clay. The Lower Aquifer wells will be double-cased through the Upper Aquifer. The installation depth of each well are discussed in the Pre-Design Work Plan. . The new wells will be sampled during the first Detection/Compliance Monitoring sampling round.

Residential Well Monitoring

The goal of the residential well monitoring program is to determine if groundwater contamination from the ACS site is impacting residential drinking water. Samples collected during the RI did not detect contamination of residential drinking water, consistent with the RI groundwater monitoring well results. The Detection Compliance Groundwater Monitoring System will be used to determine the need for the collection of samples from nearby residential wells, and to determine which wells will be sampled.

If sampling of residential wells is conducted, the samples will be analyzed for CLP VOCs, SVOCs, PCBs, or selected metals at DQO Level IV using the CLP Statement of Work according to the QAPP and FSP. The results will be provided to the U.S. EPA and the IDEM, who will be responsible for providing the results to the well owners/users.

Wetland Sampling

Surface water samples will be collected from the drainage ditch that runs on the north and west of the wetlands and a tributary (Figure 3-3) One surface water sample will be collected at an upstream location and four in downstream locations and within pooled water within the wetlands (i.e., the tributary). The upstream sample location will provide an indication of the quality of the surface water entering the ditch from off-site. Surface water samples from the ditch will provide an indication of the quality of the groundwater discharging to the wetlands, although such samples will also include potential effects from upstream influences and groundwater discharge from areas on the opposite site of the ditch from ACS. Samples will also be collected from standing water in the wetlands, if possible. Water samples of standing water in the wetlands would provide the best data to evaluate the potential impacts of groundwater discharge to the wetlands, and up to three such samples may be substituted for downstream ditch samples as conditions permit. Surface water samples will be analyzed for VOCs, SVOCs, PCBs, zinc, cadmium, lead, mercury, cyanide, and iron at Level IV DQO using CLP Statement of Work according to the QAPP and FSP.

CHEMICAL HAZARD SUMMARY

Site Chemical Hazards

Substances of Concern - A wide variety of potential substances of concern have been identified at the ACS Site. The following discussion highlights those chemicals, chemical groups, and materials which appear to pose the greatest health

and safety concerns (Appendix B). These are discussed in relation to the matrix (i.e., soils, surface water, sediment, groundwater) in which they occur. All sample matrixes indicate contamination to some extent.

Health and Safety Related to Substances of Concern - Because the number of individual organic and inorganic chemicals and compounds is so extensive, it would be excessive to discuss each one individually. Therefore, they are discussed below as groups or classes.

Polynuclear Aromatic Hydrocarbons (PAHs) - This group includes a great number of chemical compounds which are common in our environment and vary widely in their potential impact on human health. Some of the most powerful carcinogens are PAHs. Most PAHs occur in the environment as complex mixtures which consist of both carcinogenic and non-carcinogenic PAHs. The toxic effect of PAHs through absorption (by way of inhalation, ingestion, or dermal contact) appears to be based on a high level of exposure over a relatively long time period.

Halogenated Hydrocarbons - These compounds are highly mobile, migrating easily through water, air, and soil. They are persistent in the underground environment, although they may degrade at the surface under the influent of ultra-violet light.

Halogenated hydrocarbons may act on the central nervous system, either as a stimulant or depressant. Mild exposure may cause such symptoms as dizziness, nausea, abdominal pain, and vomiting. In chronic (long-term) exposure, loss of weight and appetite may occur. Moderately severe exposure presents those symptoms given above followed by severe irritability, convulsive seizures, and coma. Compounds from this class of chemicals detected at the site include:

1,2-Dichloroethene - a colorless, volatile liquid with a pleasant odor. Used as a solvent in perfumes, lacquers, thermoplastics, and organic synthesis. Produces drowsiness and effects the central nervous system.

1,1,1-Trichloroethane (Methyl Chloroform) - a clear, non-flammable liquid used primarily as a cleaning solvent. It may affect the gastrointestinal tract and the central nervous system. May cause anesthesia and death at high concentration (14,000-15,000 ppm). Lower concentration exposures, repeated daily, do not generally produce significant health effects.

Trichloroethylene (TCE) - a colorless, non-flammable liquid with a sweet odor like chloroform. Can be adsorbed through the skin. Inhalation and ingestion are also routes of exposure. Symptoms of exposure include headaches, dizziness, disturbed vision, nausea, vomiting, and eye irritation. Fatalities have occurred following severe, acute exposures. It has been known to cause cancer in laboratory animals.

Vinyl Chloride - an easily liquified gas with a faintly sweet odor. It may

affect the central nervous system, liver, respiratory system and lymphatic system. It is a known carcinogen.

Methylene Chloride - as a pure produce, methylene chloride is a colorless liquid with a chloroform-like odor (pleasant to sweet odor). With a vapor pressure of 350 mm and a boiling point of 140°F, methylene chloride volatilizes at standard or elevated temperatures. Methylene chloride inhalation can induce narcosis, affect the central nervous system and blood, cause nausea, dermatitis, numbness or tingling of the extremities, and accelerated pulse rate. Skin contact may cause irritation of the skin and/or eyes. Exposure to high concentrations may produce vertigo and angina. Primary routes of exposure include inhalation, ingestion and skin or eye contact. Although methylene chloride has produced tumors and cancer in laboratory animals, it is currently not classifiable in reference to human carcinogenicity.

Light Aromatic Hydrocarbons - Compounds in this group are highly volatile, moderately soluble, biodegradable, and only slightly adsorbed on soils and sediments. Their presence at the surface is based on volatilization rates and biodegradation activities. In the groundwater environment, they are persistent and mobile. Exposure to these substances is primarily through vapor inhalation, although absorption through the skin may also readily occur. Acute exposure poses the primary health hazard of these substances. Low level exposure may result in irritability, excitability, muscle tremor, and headache. Some of the more notable light aromatic compounds which are present include ethyl benzene, xylene, and toluene.

Benzene - colorless, flammable liquid with aromatic odor, Benzene is classified as a human carcinogen.

Ethylbenzene - colorless, flammable liquid with aromatic odor. Explosive limits of 1% to 6.7% by volume in air. Toxicity is characterized by irritancy to skin and, to less extent, mucous membranes. Prolonged exposure may cause chest constriction leading to congestion of the brain and lungs with edema.

Xylene - clear, flammable liquid with aromatic hydrocarbon odor. Exposure symptoms include headache, eye irritation, fatigue, irritability, nausea, and anorexia. Chronic exposure may result in injury to heart, liver, and/or kidneys.

Toluene - flammable, colorless liquid with aromatic hydrocarbon odor. Explosive limits of 1.3% and 7.1% by volume in air. Prolonged exposure has acted as a mutagen in experimental animals.

Phenol - Phenol is a solid or liquid with sweet tarry odor similar to railroad ties. Explosive limits 1.7% to 8.6% by volume in air. Exposure symptoms -

will burn eyes and skin and it acts as a poison on the central nervous system. The analgesic action may cause loss of pain sensation. Prolonged exposure has acted as a carcinogen and mutagen in experimental animals.

PCBs - These compounds are readily absorbed through the skin and permeate most protective clothing within a relatively short time period. Exposure to PCBs may cause chloracne (a reddish eruption of the skin), irritation of the respiratory system, and liver damage. PCBs have been shown to cause birth defects in developing fetuses and are suspected of carcinogenic activity. The members of this group have low vapor pressures and thus do not volatilize quickly. The greatest threat of exposure comes from direct contact with contaminated soils and waters, or by inhalation of contaminated dusts or aerosols.

Heavy Metals - Heavy metals may become absorbed onto soil particles and therefore are of concern if dry, dusty conditions prevail. Chronic overexposure may cause brain damage, gastrointestinal disturbances, anemia, and kidney damage.

Ingestion or inhalation of chromium may lead to histologic fibrosis of the lungs. This element is also a suspected carcinogen. Chromium poses a potential health risk by inhalation, ingestion, or skin absorption. Exposure to chromium may cause an allergic type reaction producing dermatitis or lung irritation. Symptoms of exposure may include coughing, wheezing, headaches, difficult breathing, and fever. The skin may become red, inflamed, itch, and ulceration may occur.

Nickel and soluble nickel compounds are capable of producing sensitization dermatitis and/or allergic asthma in certain individuals. Furthermore, inhalation of many nickel compounds via their presence on airborne dusts can produce severe irritation of the nasal cavities and pneumonitis. Some of these compounds have been proved to be cancer producing in humans via inhalation. Care should be taken to prevent any skin contact with and/or inhalation of dusts containing such compounds.

Cadmium compounds are possible human carcinogens with high oral and inhalation toxicities. The inhalation of dusts containing such compounds primarily affects the respiratory tract, but the kidneys and liver may also be affected with exposures to high concentrations. Possible symptoms of exposure include pulmonary edema, dryness of the throat, cough, headache, shortness of breath, and vomiting. More severe exposures result in marked lung changes, persistent cough, pain in chest, severe dyspnea, prostration with possible fatal results. Ingestion of cadmium compounds may result in sudden nausea, salivation, vomiting, diarrhea, and abdominal pain and discomfort.

Cyanide - Most cyanide compounds and hydrogen cyanide (HCN) gas can be readily absorbed through the skin. Inhalation of HCN or dust of cyanide compounds and ingestion of cyanide compounds are also a route of entry. Skin absorption is accelerated by sweating and the presence of open wounds. Once

cyanide has entered the body, it acts as a very rapid acting blood poison interrupting the transport of oxygen.

Cyanide and cyanide compounds are mainly of concern in regard to the respiratory dangers they present. Hydrogen cyanide gas and volatile cyanides are all highly toxic by brief, high level exposures and can cause death. Cyanide is a noncumulative poison, and therefore chronic toxicity is not a major concern. Acute exposure to hydrogen cyanide may result in symptoms such a headache, weakness, changes in taste and smell, irritation of throat, vomiting, difficulty breathing, abdominal colic, and nervous instability. Hydrogen cyanide has the characteristic faint odor of bitter almond.

MSDS for representative compounds are presented as Appendix B.

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3

SITE BOUNDARIES AND ENTRANCE/EXIT

SITE AND PROJECT BOUNDARIES

See Appendix C which contains a map of the site indicating boundaries of the site and project activity locations (Figure 3-1). Each project activity will be performed within the site boundary, with the exception of the proposed Geoprobe groundwater and wetland sampling activities, shown on Figure 3-2 and Figure 3-3 respectively. Based on wind information from the Midwest Climate Center, prevailing wind direction at the site is generally from the south (Figure 2).

PRESENT SITE SECURITY

The ACS manufacturing plant is enclosed within a chain link fence. Prior to starting site activities, Montgomery Watson personnel should check-in with Jim Murphy at the ACS office. Fencing is present around the landfill portion of the site and around the ACS facility which should prevent the exposure of unauthorized, unprotected people at the site. The existing chain link fence is six feet high with three strands of barbed wire at the top meeting the requirements of the SOW.

SITE SECURITY UPGRADES NEEDED

At a minimum, all areas not already fenced will be marked with yellow caution tape to prevent unauthorized entry into the work area. The SSO will ensure that security measures are adequate to protect the general public from hazards associated with operations. Field activities performed at the On-Site Containment Area are secured by the ACS faciltiy gate entrance. The Off-Site Containment Area security fence will be locked both during field activities, and at the end of each work day. Security will be maintained by verbal commands, when

appropriate. Such commands may consist of "This site is a U.S. EPA Superfund Site. Unless you have authorization to be here, please leave immediately". No unauthorized individuals will be allowed on-site.

Work zones in and around the Site will be defined by the SSO prior to the initiation of Site activities. If deemed necessary, the overall work site will be delineated into Exclusion, Decontamination, and Support Zones. Decontamination zones will be set up in the On-Site Containment Area (Figure 3-4) and the Off-Site Containment Area (Figure 3-5). The areas of active work plus a buffer zone will comprise the Exclusion Zone during operations at the Site. The size of this buffer zone is to be determined in the field by the SSO. Each zone will be clearly defined with physical demarcation devices in accordance

with prudent practices and applicable guidelines. Only personnel actively involved in project work will enter these areas during operations.

Exclusion Zone

The Exclusion Zone defines the area where contamination is known to exist or potentially exists. Personnel entering the Exclusion Zone must wear prescribed Levels of Protection. An entry and exit check point will be established at the periphery of the Exclusion Zone to regulate the flow of personnel and equipment in and out of the zone, and to verify that entry and exit procedures are followed.

The outer boundary of the Exclusion Zone may need to be delineated (at least in part) by a "hotline", consisting of survey stakes and flagging. This will delineate specifically identified "high hazard" areas such as leachate seeps, drainage, spills, hazardous work areas (e.g., drilling locations or test pit locations), etc.. Factors which will be considered in positioning the "hotline" include the distances needed to prevent fire or an explosion from affecting personnel outside the zone, the physical area necessary to conduct Site operations, and the potential for airborne dispersal of contaminants from the area. The "hotline" may be modified and adjusted during operations, as more information becomes available.

Based on current information, a site-wide Exclusion Zone is not warranted, and thus will not be established at the Site. Exclusion Zones will be established at any identified "high hazard" areas. Otherwise, Exclusion Zones will generally be restricted to drilling operations and test pit excavations, encompassing an approximate twenty-meter radius outward from these areas, whenever location permits.

Decontamination Zone

The Decontamination Zone includes the area immediately surrounding the Exclusion Zone. This zone lies at the interface of the Exclusion Zone and the Support Zone, and provides for the decontamination of equipment and personnel before crossing into the Support Zone. Contaminated protective equipment, such as respirators, hoses, boots, etc., shall not be removed from the Decontamination Zone. The Decontamination Zone serves as a buffer to further reduce the probability of the clean area (Support Zone) becoming contaminated or being

affected by other existing hazards.

Support Zone

The Support Zone covers all areas which lie both outside of the Decontamination Zone and within the Site boundary. This area is considered to have no significant air, water, or soil contamination, and therefore presents no potential hazard to on-site personnel. The Support Zone provides an area for the performance of on-site, non-hazardous activities and acts as a staging area for personnel entering the Decontamination and Exclusion Zones.

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4

GENERAL SITE HEALTH AND SAFETY CONSIDERATIONS

WEATHER CONDITION RESTRICTIONS

The Site Safety Officer (SSO) has the authority, should severe weather threaten, to place site activities on standby, cease operations and/or evacuate the Site as deemed necessary.

Weather conditions on Site can not be controlled. Site personnel are to be aware of the warnings of impending severe weather and the precautions that are to be taken when severe weather threatens. Refer to the SOP for Severe Weather found in Appendix D.

TEMPERATURE STRESS

Hot or cold weather is generally a consideration at any site and can not be controlled. Site workers need to be aware of engineering controls which can reduce temperature stress, the signs and symptoms of temperatures stress and first aid measures for victims of temperature stress. Refer to the SOP for Temperature Stress found in Appendix E.

GENERAL SITE HEALTH AND SAFETY RULES

Some general safe work practices apply to all sites. Refer to the SOP for General Site Health and Safety Rules found in Appendix F.

HEAVY EQUIPMENT

Special safety procedures are required when working around operating heavy equipment. Heavy equipment includes, backhoes, scrapers, loaders, bulldozers, trucks and drill rigs. Hazards associated with operating heavy equipment include obstructed view, moving parts, rollover, overhead clearance, noise and dust.

- Heavy equipment should be operated by trained, authorized personnel.
- Equipment should be inspected daily.
- Equipment should be equipped with backing alarms and if driven over uneven terrain rollover protection and seat belts.
- Personnel working on the equipment or in the area should wear safety glasses with side shields, steel-toe steel-shank safety boots, and hard hats.
- A spotter should be used when backing up to avoid blind spots.
- All guards should be in place and safety switches should be operational.
- Drill rigs and other equipment with tall booms should, at a minimum, remain at least 10 ft from overhead power lines and should not be moved with the boom raised.

The use of heavy equipment presents its own inherant hazards and observers and non-essential personnel should remain a safe distance from these operations.

TRAFFIC

If personnel will be in a roadway or within 10 ft of a roadway during work activities, orange safety vests must be worn. Barricades and warning signs and/or cones may be required. The SSO will determine if additional measures are warranted and will implement necessary control measures. Follow the procedures in Appendix F - General Site Health and Safety Rules.

BIOLOGICAL HAZARDS

There is a potential for additional hazards at the site which include biological hazards.

- Biological - Occupationally induced infection can occur in any occupation as a result of exposure to bacteria, viruses, fungi, or parasites. A simple laceration from a sharp edge can become secondarily infected with staphylococci or streptococci. A thorn, a wood splinter, or a metal slug

acting as a foreign body can pave the way for secondary infection of the skin. Cuts, scrapes, or other lacerations should be cleaned, disinfected, and dressed immediately following standard first aid procedures.

- Plants - A broad variety of plants and wood cause injury to skin through primary irritation or allergic sensitization. Although the chemical identity of many plant toxins has not been established, it is well known that an irritant or allergenic agent can be present in the leaves, stems, flowers, bark, and other components of the plant. Examples include, poison ivy and sumac. Personnel will be wearing long pants at the site. If work is to be performed in areas with poison ivy or sumac, contact with the plant should be avoided. The SSO will identify locations where poisonous plants are present during daily site briefings. Personnel may need to wear gloves or chemical resistant clothing (Tyvek). If contact is made with poison plants, remove contaminated clothing, wash all exposed areas with soap and water followed by rubbing alcohol. Apply calamine or other soothing skin location. Seek medial advice if severe reaction occurs.

- Insects - Insect bites and stings can be serious to hypersensitive persons and even deadly depending on the type of insect. Examples include bees, wasps, hornets, brown recluse spiders, and ticks. Lyme disease is a tick-borne disease and starts out with flu-like symptoms but may lead to arthritis and serious nerve and heart damage. Avoid tall grassy areas or other areas of thick vegetation. If work is performed in these areas, personnel should wear light colored clothing, tape pant's cuffs around their ankles, use a commercially available repellant and check for ticks regularly.

- Animals - Animal bites are a concern because of the potential for the animal to carry the rabies virus, which attacks the nervous system. If an animal bit occurs the victim must be taken to the nearest medical facility immediately.

EXCAVATIONS

Test pit excavation activities will be performed as part of the pilot/treatability testing. The Site Safety Plan will be ammended with the 50% and Final Design deliverables. Other excavations are not anticipated to be present at the site. If open excavations are encountered, personnel will refrain from entering them.

UTILITIES

All utilities must be cleared before performing any intrusive activities. The SSO will verify that utilities have been cleared before work begins at the site. Utility companies notified under the Indiana Dig Service are presented in Table 4-1.

NOISE

Hearing protection is required when working in close proximity to heavy equipment, the level of noise interferes with communications or the sound level exceeds 85 dB. Generally, if you cannot hear someone speaking at a normal conversational level when they are 3 ft from you, you need hearing protection. **Hearing protection is required within 50 ft of the following operations:**

- Driving casing or the split spoon sampler
- During core drilling
- Use of power tools
- Use of air compressor
- Use of other machinery

CONFINED SPACES

Confined space entry is not allowed under the scope of this SSP. Should a confined space entry situation be encountered, the Health and Safety Manager must be notified and provisions for confined space entry must be added to this SSP.

FALL HAZARDS

If work is performed on an elevated level six (6) feet above the ground or work surface, fall protection is required. Fall protection may still be necessary for heights less than six feet in certain situation if there is a potential for injury from falls at lower heights. These may include falls onto protruding rebar or other sharp objects. The SSO will be responsible for implementing the fall protection program as outlined in Appendix F - General Site Health and Safety Rules. Ladders also pose a significant hazard associated with falls. The guidelines in Appendix F should also be used if ladders are present at the site.

WATER HAZARDS

Workers working near water, where a danger of drowning exists, will wear U.S. Coast Guard approved life jackets. The SSO will inspect life jackets before and after each use. Defective life jackets will be taken out of service and destroyed. When working from boats or barges ring buoys with at least 90 feet of line will be available for emergency rescue. A lifesaving skiff will be available when working form barges for rescue purposes.

ELECTRICAL HAZARDS

Electrical Cords

Electrical cords passing through work areas should be covered or elevated to protect the cord from damage and reduce hazards to employees.

Extension cords used with portable tools will be 3-wire type and will be protected from damage when in use. Extension cords must be inspected on a routine basis. Cords with cuts in the insulation or that are worn or frayed or have insulation pulled back from the plug or receptacle fittings will be taken out of service immediately.

Grounding

Portable tools and other electric equipment will be grounded or double insulated. Ground fault circuit interrupters (GFCIs) will be used in wet areas and on all field sites and outdoor operations if power is supplied through the utilities. GFCI's are not required on portable generators rated less than 5kW which are single phase, two wire type.

HOT WORK

Hot work involves the use of open flames or other sources of heat around possible sources of flammable vapors. Hot work is not permitted under the scope of this SSP. The SSO will be responsible for fire control measures as outlined in Appendix F - General Site Health and Safety Rules.

LIFTING/MATERIALS HANDLING

Lifting and materials handling are hazards during operations. Follow the procedures outlined in Appendix F - General Site Health and Safety Rules when lifting objects or handling materials.

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CHEMICAL HAZARD EVALUATION/ AIR MONITORING STRATEGY

The following air quality parameters will be monitored during work activities:

- Oxygen Level
- Combustible Gases
- Hydrogen Sulfide
- Hydrogen Cyanide
- Vinyl Chloride
- Volatile Organic Compounds (VOCs)
- Other Compounds

MSDS equivalents for specific compounds noted above are included in Appendix B.

AIR MONITORING STRATEGY

Oxygen
A direct reading oxygen meter (Industrial Scientific) will be used to determine the percent of oxygen in the atmosphere.

Instrument Reading	Action to be Taken
<19.5% or >23.5%	Cease operations and move to a safe area. Re-evaluate the work plan. Engineering controls such as forced ventilation and use of non-sparking tools are to be implemented if operations are to continue. **DO NOT CONTINUE WORKING UNTIL OXYGEN LEVELS ARE BETWEEN 19.5 AND 23.5%.** When oxygen levels are outside this range, combustible gas meter readings are not reliable.

Combustible Gases

Action levels are based on the readings of a Industrial Scientific combustible gas meter. The readings are generally given as a percentage of the lower explosion limit (% LEL).

Instrument Reading	Action to be Taken
0 to 10% LEL	Continue working and monitoring the atmosphere for combustible gases. Inform personnel working in the area whenever readings are >5% LEL.
10 to 20% LEL	Continue working with caution. Inform personnel working in the area of the readings. Be prepared to cease operations.
> 20% LEL	Cease operations and move to a safe area. Re-evaluate the work plan. Engineering controls such as forced ventilation and use of non-sparking tools are to be implemented if operations are to continue. **DO NOT CONTINUE WORKING UNTIL CONDITIONS ARE CONSISTENTLY BELOW 20% LEL.**
NOTE	When oxygen levels are above 23.5% or below 19.5%, combustible gas meter readings are not reliable.

Hydrogen Sulfide (H_2S)

A direct reading H_2S meter (Industrial Scientific) will be used to determine H_2S levels. Whenever the alarm sounds on the H_2S meter, cease work immediately and contact the SSO or HSM. For H_2S the TLV is 10 PPM, and the alarm is set for 10 PPM.

If approval is given by the SSO or HSM, verification of the presence of H_2S is to be made using colorimetric tubes which can detect H_2S. The person taking the sample is to wear appropriate respiratory protection. There is no air-purifying cartridge approved for use in an atmosphere containing H_2S. A supplied-air respirator must be used.

If the present of H_2S is confirmed, cease activities and contact the HSM. If the colorimetric tubes do not indicate the presence of H_2S, continue with site activities cautiously and continue to monitor for H_2S with the direct reading meter. Hydrogen sulfide is an olfactory depressant and therefore, the sense of smell cannot be relied upon.

Hydrogen Cyanide (HCN)

A direct reading HCN meter (Monitox) will be used to determine HCN levels. Whenever there is any positive reading on the HCN meter, cease work immediately and contact the Site Safety Officer (SSO) or Health and Safety Manager (HSM). The TLV-C (ceiling) for HCN is 4.7 PPM, and the alarm is set for 4 PPM.

If approval is given by the SSO or HSM, verification of the presence of HCN is to be made using colorimetric tubes which can detect HCN. The person taking the sample is to wear appropriate respiratory protection. There is no air-purifying cartridge approved for use in an atmosphere containing HCN. A supplied-air respiratory must be used.

If the presence of HCN is confirmed, cease activities and contact the HSM. If the colorimetric tubes do not indicate the presence of HCN, continue with site activities cautiously and continue to monitor for HCN with the direct reading meter.

Vinyl Chloride

Whenever any reading above background is noted with the organic vapor monitor, colorimetric tubes will be used continually during intrusive activities to verify the presence of vinyl chloride. If vinyl chloride is found to be present above 1 ppm, personnel will cease operations and contact the Health and Safety Manager. There is no air-purifying cartridge approved for use in an atmosphere containing vinyl chloride. A supplied-air respirator must be used.

Volatile Organic Compounds (VOCS)
Photoionization meter (Thermo Environmental or HNu) with a lamp rating of 11.7 eV

Action Levels:

< Background: Level D or D-Modified*

< 5 Instrument Units above background: Level C

5 to 50 Instrument Units above background: Level B

≥ 50 Instrument Units above background: Cease operations and move to a safe area. Contact the Health and Safety Manager and re-evaluate the work plan.

* Level D is to be used when there is no dermal contact with contaminated materials. Level D-Modified is to be used when there is dermal contact with contaminated materials.

Dust
A dust control program will be used to limit contaminant dispersion. Prevailing winds are generally westerly, but stakes with flagging will be used to determine wind direction and aid in dust control measures.

Dust may be generated during the following activities.

- Movement of vehicles on unpaved roads.
- Movement of soils by bulldozers, backhoes, and front end loaders.
- Wind erosion from stockpiled soils

Dust control measures will be implemented during construction activities on site. Specific dust control measures will be chosen by the subcontractor performing the work and may include the following:

- Compacting unpaved roads as much as possible.

- Watering the roads with a water wagon or spray bar. Materials sprayed may include plain water, salt solutions, surfactants, and/or adhesives.

- Speed control of vehicles using the road.

- Control of emissions from movement of soil by bulldozers, front end loaders, and backhoes (with such a high water table most soil excavated will be very moist and additional measures are not likely necessary).

- Control emissions from soil stockpiles by covering the soil pile or erecting a wind screen, and/or spray the pile with water or chemical dust suppressants to compact and weight soil particles.

If visible dusty conditions persist after dust control measures are implemented, the SSO will initiate and upgrade to Level C protection.

FREQUENCY

Perform air monitoring whenever any of the following situations arise:

- Upon initial entry to a site to rule out IDLH conditions
- Work begins at a different portion of the site
- New contaminants are noted
- A new/different phase of work is started
- Work is being performed in areas with obvious liquid contamination
- Continuously during intrusive activities
- Continuously during confined space entry

Monitoring should be performed on personnel with the highest potential exposure. If samples are being collected in jars, use monitoring equipment to determine the level of contaminants in the breathing zone of the person collecting the samples. Do not use instantaneous readings to determine the level of protection. Readings should be persistent unless "pulses" of vapor exceed STEL or Ceiling levels. Monitoring should also be performed at the source of chemical hazards such as boreholes and the surface of contaminated materials but upgrades are based on breathing zone concentrations.

CALIBRATION REQUIREMENTS

Calibrate all monitoring equipment at the beginning and end of each work day.

Calibration data will be recorded in a bound field notebook or in the field notes. Documentation should include:

- Date/time
- Zero reading before calibration
- Concentration of calibration gas
- Reading obtained with calibration gas before adjusting span
- Final reading obtained with calibration gas after adjusting span

When air monitoring is required, take area air samples at the following locations daily, in addition to any other air monitoring required by this plan. Record time, location and results of monitoring and actions taken based upon the readings:

- Upwind of work areas to establish background air contaminants
- In Support Zone to check for contamination
- Along decontamination line to check that decontamination workers are properly protected and on-site workers are not removing protective equipment in a contaminated area
- Exclusion Zone to verify level of protection and Exclusion Zone boundaries
- Downwind of work area to track any contaminants leaving site

Use the SOPs for equipment calibration in the Montgomery Watson Instrument SOP Manual. Manufacturer's information regarding each piece of air monitoring equipment utilized at the site is presented in Appendix K.

REQUIRED PERSONAL PROTECTIVE EQUIPMENT

Level D

Level D is to be worn during activities which do not suggest any initial respiratory or dermal health hazards. The following list outlines the personal protective equipment to be utilized for Level D.

- Work Uniform
- Safety Boots - Steel toe/steel shank
- Hard Hat
- Safety Glasses with side shields*
- Face Shield*
- Hearing Protection*

Level D-Modified
Level D-Modified is to be worn during activities which do not suggest any respiratory hazards, but where dermal protection is warranted.

- Safety Boots - Steel toe/steel shank
- Hard Hat
- Safety Glasses with side shields*
- Face Shield*
- Hearing Protection*
- Outer Gloves - MOC:Neoprene or Nitrile
- Boot Covers - MOC:Latex
- Chemical Resistant Clothing - MOC:Polyethylene-coated Tyvek
- Inner Gloves - MOC:Nitrile

Level C
Level C should be worn where the criteria for using air-purifying respirators are met, and a higher level of dermal protection is needed. Criteria for using an air purifying respirator include chemicals with good warning properties, oxygen between 19.5 and 23.5% and a chemical cartridge must be available for chemicals in question.

- Safety Boots - Steel toe/steel shank
- Hard Hat
- Face Shield*
- Hearing Protection*
- Outer Gloves - MOC:Neoprene or Nitrile
- Boot Covers - MOC:Latex
- Chemical Resistant Clothing - MOC:Hooded, Polyethylene-coated Tyvek
- Full-Face Air Purifying Respirator
- Respirator Cartridge - Type:organic vapor/acid gas
- Inner Gloves - MOC:Nitrile

Level B
Level B is worn where the highest level of respirating protection is needed and a higher level of dermal protection is required. Level B is the primary level of choice in unknown environments.

- Safety Boots - Steel toe/steel shank
- Hard Hat
- Face Shield*
- Hearing Protection*
- Outer Gloves - MOC:Neoprene or Nitrile
- Boot Covers - MOC:Latex
- Chemical Resistant Clothing - MOC:Hooded, Polyethylene-coated Tyvek
- Positive Pressure/Pressure Demand Self Contained Breathing Apparatus or Airline Respirator with Escape Bottle
- Inner Gloves - MOC:Nitrile

* Optional PPE - Use as needed.

Respirators will be used following proceedures in Appendix N - Respriatory Protection Equipment.

Note: Safety glasses are required within 50 ft of operating equipment, tools or machinery. Face shields are required during operations that may cause materials to fly into or spray the face. These include:

- Sawing metal or concrete
- Grinding or sanding operations
- In the vicinity of drilling operations when mud and liquids are sprayed in the work area
- When opening drums or tanks when hazardous materials under pressure are potentially present
- Cutting with a torch or when welding

TASK SPECIFIC LEVELS OF PROTECTION

Monitoring Well Installation/Soil Sampling/Sediment Sampling/Soil Borings
Potential Hazards: VOCs, severe weather, temperature stress, heavy equipment, biological hazards, utilities, and noise.

Hazard Evaluation: Low to moderate.

Principle Route of Chemical Exposure: Dermal contact and inhalation.

Level of Protection: For monitoring well installation, surface water and sediment sampling, Level D health and safety protection has been used in past activities and is anticipated to be applicable to these tasks, since this work is performed outside the limits of waste. For soil borings advanced near the waste area on-site and off-site, Level D-Modified has been applicable in past investigations. If air monitoring indicates the presence of VOCs above background, upgrade to Level C protection will be performed. Field personnel will be able to modify to Level B protection if air monitoring indicates this to be necessary.

Air Monitoring: Continually during drilling (intrusive) activities for Organic vapors, vinyl chloride, oxygen, explosive vapors, vinyl chloride, hydrogen sulfide, hydrogen cyanide in fill areas. Organic vapors and vinyl chloride only outside fill area.

Groundwater Sampling/Groundwater Elevation Measurement/Surface Water Sampling

Potential Hazards: VOCs, severe weather, temperature stress, and biological hazards.

Hazard Evaluation: Low

Principle Route of Chemical Exposure: Dermal contact and inhalation.

Level of Protection: For these tasks, Level D protection has been used in the past and is applicable. Monitoring wells which have shown considerable contamination in the past will be performed in Level D modified protection.

Air Monitoring: During the initial opening of each monitoring well for organic vapors, VOCs

Geoprobe Sampling

Potential Hazards: Explosive vapors, VOCs, hydrogen sulfide, hydrogen cyanide, severe weather, temperature stress, heavy equipment, biological hazards, utilities, and noise.

Hazard Evaluation: Low to moderate.

Principle Route of Chemical Exposure: Inhalation, dermal contact.

Level of Protection: Geoprobe sampling will be performed outside the site boundary limits where groundwater results have shown minimal, if any, groundwater impact. This work will be performed in Level D protection. If field screening (PID readings) or visual observations indicate potential contamination, field personnel will upgrade to Level D-modified.

Air Monitoring: During intrusive activities for Oxygen, explosive vapors, organic vapors, vinyl chloride, hydrogen sulfide, hydrogen cyanide in fill areas. Organic vapors and vinyl chloride only outside fill area.

Drum Consolidation/Waste Sampling

Potential Hazards: Explosive vapors, VOCs, hydrogen sulfide, hydrogen cyanide, severe weather, temperature stress, heavy equipment, biological hazards, noise.

Hazard Evaluation: Moderate to high.

Principle Route of Chemical Exposure: Dermal contact and inhalation.

Level of Protection: Drum excavation and waste sampling have been performed in Level C protection on past occasions. If air monitoring indicates an upgrade is necessary to Level B protection, job activities will be ceased, and upgrade to

proper health and safety protection will be performed.

Air Monitoring: During drum opening and sampling activities for Oxygen, explosive vapors, organic vapors, vinyl chloride, hydrogen sulfide, hydrogen cyanide.

Special Work Practices: See Appendix O.

Elevation and Location Survey
Potential hazards: Severe weather, temperature stress and biological hazards.

Hazard Evaluation: Low

Principle Route of Chemical Exposure: Dermal contact.

Level of Protection: Elevation and location surveys at the ACS facility have been performed in Level D protection in the past and is applicable for this activity.

Air Monitoring: None required.

PERSONAL DECONTAMINATION

Use the SOP for Decontamination at the highest level of protection used on Site each day, found in Appendix G.

EQUIPMENT DECONTAMINATION

Decontamination of all heavy equipment will be performed in designated areas. Decontamination will involve a high-pressure steam-cleaning of all equipment which will come in contact with subsurface material at the On-Site Containment Area (Figure 3-4) and the Off-Site Containment Area (Figure 3-5). Decontamination pads will be constructed in each of these areas for containing decontamination residuals. Each pad will be constructed so the wastewater will slope towards a sump collection container. Water will then be transferred to drums for storage and proper future disposal. Additional scrubbing may be required to remove encrusted materials. Decontamination of heavy equipment will occur between boreholes, as well as at the completion of such equipment's use on Site.

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INVESTIGATION DERIVED MATERIALS DISPOSAL

DISPOSABLE CLOTHING/EQUIPMENT

Drum and label the materials and leave on-site for proper future disposal.

DRILL CUTTINGS

Drill cuttings will be screened with a photoionization detector (PID) and retained in 55-gallon drums on-site. Drums will be labeled as needed to identify contents and source locations. Investigation derived waste will be stored onsite and treated with the waste during the Remedial Action Phase.

DRILLING/DECONTAMINATION/PURGE WATER

Water generated during drilling operations, well purge water, and decontamination solutions will be screened with a photoionization detector (PID), and retained in 55-gallon drums on-site. Drums will be labeled to identify contents and well locations if applicable. The liquid waste will be treated by the groundwater treatment system.

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EMERGENCY INFORMATION

	Address	Telephone or Mobil*	Contact Person
Ambulance		911 or *999	
Hospital E/R	Munster Community Hosp. 901 McArthur Boulevard Munster, Indiana	(219) 836-1600	
Poison Control		(800) 942-5969	
Police		911 or *999	
Fire		911 or *999	
Client		(219)	
EPA/other agency	U.S. EPA	(312) 353-2318	
Utilities	Indiana Dig	(800) 382-5544	
Chemtrec		(800) 424-9300	
Spill Response			

*Note: when using a mobile telephone, *999 only works on state highways, otherwise dial "0" for operator assistance to direct you to the appropriate emergency service.

Emergency Contacts	Name	Business Phone	Home Phone
Project Manager	Peter J. Vagt	(708) 691-5065	(312) 284-7332
Site Safety Officer	David Pieczynski	(708) 691-5069	(708) 372-0346
H&S Coordinator	David Pieczynski	(708) 691-5069	(708) 372-0346
H&S Manager	Beth Darnell	(714) 222-1844	(714) 222-1844
Site Manager (alt)	Phil Smith	(708) 691-5052	(708) 369-7355
Construction Mgr.	Eric Pedersen	(608) 231-4747	

EMERGENCY ROUTES

See Appendix C for a map showing the route to the hospital/clinic.

Driving Directions
Exit site onto Colfax north to Main Street. Take left onto Main, head west to Indianapolis Boulevard (Route 41). Take right onto 41 (north) to Ridge Road. Take left onto Ridge Road (west) to Calumet Avenue. Turn left onto Calumet Avenue (south). Hospital emergency entrance is on east side of street, just past Fisher Street.

Emergency routes are to be verified by the SSO and communicated to site personnel prior to site activities.

EMERGENCY PROCEDURES

On-site Communication System
On-Site communication procedures will be established in the field during the initial Site briefing or whenever there is a change of Site personnel. Emergency signals will be designated and discussed during this initial briefing. Employees will be made aware of routes of egress and assembly points to be used in the event of an emergency. A telephone will be accessible to Site personnel during project field activities defined under the scope of work. Emergency phone numbers will be posted in all site vehicles and site trailer. In addition, vehicle horns or other means will be used to notify personnel of on Site emergency situations. Communication in the event of a Site emergency will be determined by the SSO. Personnel will leave the Site by the most expeditious route and will assemble at a location designated by the SSO in the initial Site health and safety briefing. Additional communication information is presented in Appendix H.

Work Site Emergency Procedures
In the event of a medical emergency at a work site, personnel will act quickly and reasonably to remedy the situation. The SSO shall give directions as to how to proceed. If the SSO is incapacitated by an injury, etc., an appropriate local emergency response agency will be contacted. See Appendix H of this Health and Safety Plan for the Emergency Response SOP.

American Chemical Service, Inc. (ACS) has their own Site Safety and Health Plan (Appendix J) which incorporates an Emergency Notification System for all on-site contractors. This system will be followed while performing tasks at the facility. A summary of this emergency notification system is presented in the Section 7 of the ACS Site Safety and Health Plan.

For activities that are performed at the Off-Site Containment Area and outside site boundary limits (i.e., Geoprobe investigation), each site vehicle will contain a first aid kit, phone, and Health and Safety Plans with emergency phone numbers.

Emergency routes for these activities are presented on Figures 7-1, 7-2 and 7-3. Special care will be taken if rescue efforts are necessary. Personnel shall utilize extreme caution and take steps to be as adequately protected as possible, before attempting such rescue.

Emergency Equipment

The following emergency equipment shall be maintained at the contamination reduction zone or in the operations vehicle:

- Fire Extinguisher
- Portable Eyewash
- First-Aid Kit
- 5 Gallons of Fresh Water (for flushing of skin, general washing)

Other Emergency Procedures

- Name, address, and telephone number of the nearest medical treatment facility will be conspicuously posted. A map and directions for locating the medical facility will be readily available.

- Telephone numbers and procedures for obtaining ambulance, emergency, fire, and police services will be conspicuously posted.

- An emergency eye wash fountain and First Aid equipment shall be readily available on Site.

- The SSO will inform the local medical facility before site operations commence. The SSO will give the medical facility general information of on-site chemical hazards that may be encountered, in addition to Site location and time and dates of work activities.

- Every attempt to rapidly identify substances to which the worker has been exposed shall be made. This information will be given to medical personnel in the event of an emergency.

- Procedures for decontamination of injured workers and preventing contamination of medical personnel, equipment, and facilities shall be communicated to workers. Emergency shower are located on the ACS facility grounds. In addition, an emergency shower will be located in the support zone (Site Trailer).

Medical Emergencies

Any person who becomes ill or injured in the Exclusion Zone must be decontaminated as soon as possible, giving consideration to which risk will be greater, the spread of contamination or any potential health effects of the individual. If the victim is stable, decontamination is to be completed and First Aid administered as needed prior to transport. If the patient's condition is unstable, only gross decontamination is to be completed (i.e., removal of PPE if necessary), to prevent injury to responder, prior to administering First Aid. First Aid should be administered while awaiting an ambulance or paramedics as appropriate to the injury. Refer to the Decontamination SOP found in Appendix G of this HSP for further details.

Anyone being transported to a clinic or hospital for treatment should have available to them information on any potential chemical(s) to which they could have been exposed to at the Site, along with their medical history.

First Aid

Refer to the SOP for Chemical First Aid found in Appendix I for general chemical first aid procedures. Standard first and CPR procedures should be used in other medical emergencies. Each first aid kit contains protection equipment that must be worn while performing first aid and CPR. This includes:

- Disposable gloves
- Disposable mouth-to-mouth resuscitator
- Safety goggles/face mask
- Disposable overgarment

Whenever first aid procedures are performed on another person, the Health and Safety Manager must be notified immediately.

Personnel assigned to conduct field work for this project do not conduct first aid or cardiopulmonary resuscitation (CPR) as a primary job function. Rather, employees have been trained in CPR and first aid for emergency use only. Acting in the capacity of a designated emergency first aid provider is not mandatory, and anyone who is uncomfortable with the possibility of being so designated should notify the SSO.

An indoctrination to the bloodborne pathogens standard (29 CFR 1910.1030) has be provided to all employees either during their first aid training, and/or during the initial site health and safety meeting. Hepatitis B and Acquired Immune Deficiency Syndrome (AIDS), among other pathogenic microorganisms can be contracted during emergency first aid and CPR through contact with blood. It is important to recognize the content of universal precautions. Universal precautions require one to assume that all blood and bodily fluids contain pathogens and require the use of protective barriers to prevent exposure. Additionally, washing any body part or surface that has been contaminated with blood is an important part of the universal precautions. One last requirement is

to notify the SSO of any potential contact with blood or bodily fluids resulting from first aid or CPR administration.

A vaccine for Hepatitis B exists. Employees trained in first aid and CPR that desire the vaccine have received the series of vaccine innoculations. Latex gloves and CPR barriers will be available in the first aid kits and should be used prior to attending to the victim's needs.

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NAMES AND SIGNATURES

All Montgomery Watson employees working on or visiting this site are to sign below, indicating that they have read this Site Safety Plan (SSP), understand its contents, have been given opportunity to discuss its contents with the Site Safety Officer (SSO) and agree to abide by its requirements. Anyone entering the site shall be granted an opportunity to review the Site Safety Plan (SSP).

The supervisors of all subcontractors are to sign below, indicating that they have read this Site Safety Plan (SSP), understand its contents, and have been given opportunity to discuss its contents with the Site Safety Officer (SSO).

Date	Name	Employer	Signature

It is the responsibility of the Site Safety Officer (SSO) to have a completed and signed copy of this SSP returned to the project file.

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TABLE 1

MAXIMUM REPRESENTATIVE CONSTITUENTS

GROUNDWATER:

Compound	Maximum Concentration	Location
Acetone	9,000 ppb	Upper Aquifer
Benzene	100,000 ppb	Upper Aquifer
4-Methylphenol	2,200 ppb	Upper Aquifer
Benzoic Acid	1,900 ppb	Upper Aquifer
Calcium	1,040,000 ppb	Upper Aquifer
Sodium	444,000 ppb	Upper Aquifer
Chloroethane	440 ppb	Lower Aquifer

SOIL:

Compound	Maximum Concentration	Location
Acetone	34,000,000 ppb	Off-SiteContainmentArea
1,1,1-Trichloroethane	150,000,000 ppb	Off-SiteContainmentArea
Tolvene	130,000,000 ppb	Off-SiteContainmentArea
Ethylbenzene	23,000,000 ppb	Off-SiteContainmentArea
Xylene	100,000,000 ppb	Off-SiteContainmentArea
Benzoic Acid	32,000,000 ppb	Off-SiteContainmentArea
Naphthalene	2,400,000 ppb	Off-SiteContainmentArea
Bis (2-Ethylhexyl) Phthalate	14,000,000 ppb	Off-SiteContainmentArea
Arodor 1254	650,000 ppb	Off-SiteContainmentArea
Arodor 1260	560,000 ppb	Off-SiteContainmentArea
Calcium	157,000 ppm	Kapica/Pazmey Surface Soil

SURFACE WATER:

Compound	Maximum Concentration	Location
Acetone	380 ppb	Drainage Area
Benzene	460 ppb	Drainage Area
4-Methyphenol	590 ppb	Drainage Area
Calcium	334,000 ppb	Drainage Area
Magnesium	61,700 ppb	Drainage Area

SEDIMENT:

Compound	Maximum Concentration	Location
Benzene	14,000 ppb	Drainage Area
Xylene	200 ppb	Drainage Area
Bis (2-Ethylhexyl) Phthalate	13,000 ppb	Drainage Area
Arochlor - 1254	17,000 ppb	Drainage Area
Calcium	73,000 ppb	Drainage Area

Table 4-1
Site Utility Contacts
American Chemical Service, Inc.
Griffith, Indiana

Utility Company	Telephone Number
U.S. Cable of Northern Indiana	(219) 879-0361
Williams Telecom	(219) 234-4457 1-800-446-2658
Buckeye Pipeline	(317) 291-3121
Amoco Pipeline	(708) 990-3700
NIPSCO Crossroads Pipeline	1-800-422-6199
AT&T	1-800-222-3000
Lakehead Pipeline	(219) 879-3994
GTE North	1-800-483-4600
Ameritech	(312) 750-5000

JOB SAFETY & HEALTH PROTECTION

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers by promoting safe and healthful working conditions throughout the Nation. Provisions of the Act include the following:

Employers

All employers must furnish to employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious harm to employees. Employers must comply with occupational safety and health standards issued under the Act.

Employees

Employees must comply with all occupational safety and health standards, rules, regulations and orders issued under the Act that apply to their own actions and conduct on the job.

The Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor has the primary responsibility for administering the Act. OSHA issues occupational safety and health standards, and its Compliance Safety and Health Officers conduct jobsite inspections to help ensure compliance with the Act.

Inspection

The Act requires that a representative of the employer and a representative authorized by the employees be given an opportunity to accompany the OSHA inspector for the purpose of aiding the inspection.

Where there is no authorized employee representative, the OSHA Compliance Officer must consult with a reasonable number of employees concerning safety and health conditions in the workplace.

Complaint

Employees or their representatives have the right to file a complaint with the nearest OSHA office requesting an inspection if they believe unsafe or unhealthful conditions exist in their workplace. OSHA will withhold, on request, names of employees complaining.

The Act provides that employees may not be discharged or discriminated against in any way for filing safety and health complaints or for otherwise exercising their rights under the Act.

Employees who believe they have been discriminated against may file a complaint with their nearest OSHA office within 30 days of the alleged discriminatory action.

Citation

If upon inspection OSHA believes an employer has violated the Act, a citation alleging such violations will be issued to the employer. Each citation will specify a time period within which the alleged violation must be corrected.

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

Proposed Penalty

The Act provides for mandatory penalties against employers of up to $1,000 for each serious violation and for optional penalties of up to $1,000 for each nonserious violation. Penalties of up to $1,000 per day may be proposed for failure to correct violations within the proposed time period. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to $10,000 for each such violation.

There are also provisions for criminal penalties. Any willful violation resulting in death of an employee, upon conviction, is punishable by a fine of up to $250,000 (or $500,000 if the employer is a corporation), or by imprisonment for up to six months, or both. A second conviction of an employer doubles the possible term of imprisonment.

Voluntary Activity

While providing penalties for violations, the Act also encourages efforts by labor and management, before an OSHA inspection, to reduce workplace hazards voluntarily and to develop and improve safety and health programs in all workplaces and industries. OSHA's Voluntary Protection Programs recognize outstanding efforts of this nature.

OSHA has published Safety and Health Program Management Guidelines to assist employers in establishing or perfecting programs to prevent or control employee exposure to workplace hazards. There are many public and private organizations that can provide information and assistance in this effort, if requested. Also, your local OSHA office can provide considerable help and advice on solving safety and health problems or can refer you to other sources for help such as training.

Consultation

Free assistance in identifying and correcting hazards and in improving safety and health management is available to employers, without citation or penalty, through OSHA-supported programs in each State. These programs are usually administered by the State Labor or Health department or a State university.

Posting Instructions

Employers in States operating OSHA approved State Plans should obtain and post the State's equivalent poster.

Under provisions of Title 29, Code of Federal Regulations, Part 1903.2(a)(1) employers must post this notice (or facsimile) in a conspicuous place where notices to employees are customarily posted.

More Information

Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:

Atlanta	(404) 347-3573
Boston	(617) 565-7164
Chicago	(312) 353-2220
Dallas	(214) 767-4731
Denver	(303) 844-3061
Kansas	(816) 426-5861
New York	(212) 337-2325
Philadelphia	(215) 596-1201
San Francisco	(415) 995-5672

Elizabeth Dole

Elizabeth Dole, Secretary of Labor

U.S. Department of Labor

Occupational Safety and Health Administration

Washington, D.C.
1989 (Revised)
OSHA 2203

A

Safety Checklists

SITE HEALTH AND SAFETY CHECKLIST - COMPREHENSIVE

GENERAL INFORMATION

Date:_____ Checklist completed by: _____
Project number: _____ Project name: _____
Location: _____
Site Manager: _____ Site Safety Officer: _____
Weather: [ ] windy [ ] fair [ ] cloudy [ ] dry [ ] rain [ ] sleet
[ ] snow temperature °C/°F

SAFETY INFORMATION

[ ]Yes [ ]No [ ]N/A	Signed SSP on-site: [ ]available [ ] posted
[ ]Yes [ ]No [ ]N/A	SSP reviewed and signed by necessary personnel.
[ ]Yes [ ]No [ ]N/A	MSDSs on site for all hazardous materials brought to site by personnel. [ ] available [ ] posted
[ ]Yes [ ]No [ ]N/A	Designated SSO present.
[ ]Yes [ ]No [ ]N/A	Site safety briefing held. Date of last briefing: __/__/__
	On-site Montgomery Watson personnel meet OSHA requirements for:
[ ]Yes [ ]No [ ]N/A	• H&S training
[ ]Yes [ ]No [ ]N/A	• Medical surveillance
[ ]Yes [ ]No [ ]N/A	• Respirator fit test
	On-site Montgomery Watson subcontractors meet OSHA requirements for:
[ ]Yes [ ]No [ ]N/A	• H&S training
[ ]Yes [ ]No [ ]N/A	• Medical surveillance
[ ]Yes [ ]No [ ]N/A	• Respirator fit test
[ ]Yes [ ]No [ ]N/A	Work being done in compliance with SSP and SOPs.
[ ]Yes [ ]No [ ]N/A	Equipment specified in SSP available.
[ ]Yes [ ]No [ ]N/A	Equipment specified in SSP in working order.
[ ]Yes [ ]No [ ]N/A	Equipment manuals available.
[ ]Yes [ ]No [ ]N/A	Monitoring equipment calibrated.
[ ]Yes [ ]No [ ]N/A	Calibration records available.

[ ]Yes [ ]No [ ]N/A Responsible personnel know how to operate monitoring equipment.

[ ]Yes [ ]No [ ]N/A Adequate equipment/materials inventory available.

[ ]Yes [ ]No [ ]N/A Radiation monitoring badges being worn by all personnel working with nuclear density gauges.

Zones established and enforced:

[ ]Yes [ ]No [ ]N/A • Exclusion
[ ]Yes [ ]No [ ]N/A • Decontamination
[ ]Yes [ ]No [ ]N/A • Support/clean

Proper decontamination procedures:

[ ]Yes [ ]No [ ]N/A • Set up
[ ]Yes [ ]No [ ]N/A • Enforced

[ ]Yes [ ]No [ ]N/A Emergency telephone numbers posted.
[ ]Yes [ ]No [ ]N/A Emergency route to hospital posted.
[ ]Yes [ ]No [ ]N/A Local officials notified.
[ ]Yes [ ]No [ ]N/A At least one person on-site has current first aid and CPR certification.

Appropriate first aid materials on site:

[ ]Yes [ ]No [ ]N/A • 15 minute eye wash
[ ]Yes [ ]No [ ]N/A • First aid kit
[ ]Yes [ ]No [ ]N/A Special emergency procedures implemented.

SAFETY EQUIPMENT UTILIZED BY FIELD CREW

[ ]Yes [ ]No [ ]N/A Field/Health and Safety Equipment Checklists complete and current.

COMMENTS

Effectiveness of SSP:

Deficiencies noted:

Remedial actions required/taken:

HEALTH AND SAFETY MEETING ATTENDANCE

Date	Name	Employer	Signature

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SITE HEALTH AND SAFETY CHECKLIST - DAILY

Date: _____ Checklist completed by: _____
Project number: _____ Project name: _____
Location: _____
Site Manager: _____ Site Safety Officer: _____
Weather: [ ] windy [ ] fair [ ] cloudy [ ] dry [ ] rain [ ] sleet
[ ] snow temperature: _____ ° / °

Topic covered?

[ ]Yes	[ ]No	[ ]N/A	Site hazards
[ ]Yes	[ ]No	[ ]N/A	• General site health and safety hazards
[ ]Yes	[ ]No	[ ]N/A	• Specific hazards associated with substances of concern
[ ]Yes	[ ]No	[ ]N/A	• Routes of exposure
[ ]Yes	[ ]No	[ ]N/A	• Specific hazards associated with a task/job
[ ]Yes	[ ]No	[ ]N/A	• Physical stresses/hazards
[ ]Yes	[ ]No	[ ]N/A	• "Buddy" system
[ ]Yes	[ ]No	[ ]N/A	Site Safety Plan
[ ]Yes	[ ]No	[ ]N/A	• Role/duties of Site Safety Officer (SSO)
[ ]Yes	[ ]No	[ ]N/A	• Ambient air monitoring
[ ]Yes	[ ]No	[ ]N/A	• Emergency procedures/hospital routes
[ ]Yes	[ ]No	[ ]N/A	Personal Protection
[ ]Yes	[ ]No	[ ]N/A	• Required PPE
[ ]Yes	[ ]No	[ ]N/A	• SCBA/Air-supplying respirator review
[ ]Yes	[ ]No	[ ]N/A	• Proper donning/doffing techniques
[ ]Yes	[ ]No	[ ]N/A	Decontamination
[ ]Yes	[ ]No	[ ]N/A	• Overview of station(s)
[ ]Yes	[ ]No	[ ]N/A	• Proper techniques
[ ]Yes	[ ]No	[ ]N/A	• Field equipment decontamination
[ ]Yes	[ ]No	[ ]N/A	• Heavy equipment/machinery decontamination
[ ]Yes	[ ]No	[ ]N/A	• Vehicle movement
[ ]Yes	[ ]No	[ ]N/A	• Personal hygiene

Health and Safety Meeting Attendance

Date	Name	Employer	Signature

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EXCAVATION SAFETY CHECKLIST

(This form is to be completed daily.)

Project: _____ Project #: _____

Competent Person: _____ Date: _____

Utilities Checked

_____Telephone
_____Electric
_____Natural Gas
_____Water
_____Sewer
_____Cable TV
_____Other

Secure Surface & Overhead Structures

_____Power Poles
_____Overhead Obstacles
_____Roads
_____Buildings/Foundations
_____Sidewalks
_____Other

Trench Depth

_____0-5' _____5'-10' _____10'-15' _____15'-20' _____>20'

Egress

Ladder Present in Trench Yes No
(Ladder required at trench depths of 4' or greater)
(Ladder to extend 36" above ground surface)
(Ladder or ramp within 25' of linear travel in either direction)

Soil Classification

Visual Analysis of Soil
_____Cracks/Fissures/Spalling of Trench Sides
_____Water Seeping From Sides or Bottom
_____Different Soil in Layers
_____Soil Previously Disturbed
_____Underground Utilities Present
_____Continuous Vibration Present

Penetrometer Reading: _____

	A	B	C
Penetrometer Reading	≥ 1.5 tsf Not Previously Disturbed Stable Dry Rock	1.5-0.5 tsf Previously Disturbed Cracks Fissures	<0.5 tsf Previously Disturbed Seeping Soil Wet Soil
Maximum Slope	53 deg. (3/4:1)	45 deg. (1:1)	34 deg. (1-1/2:1)

Vehicular Traffic

Area Properly Barricaded ____Yes ____No

Reflective Clothing Warn ____Yes ____No

Flagman Present as Necessary ____Yes ____No

Protective System in Place to Prevent Vehicles Unloading Fill Materials From Backing into Excavation ____Yes ____No

Other Hazards

Check for Hazardous Atmospheres

____Oxygen ____Combustibles ____Organic Vapors ____Other

Confined Space Permit Acquired ____Yes ____No

Excavated materials and equipment at least 2 feet from edge of excavation and no other overhead hazards to personnel in excavation ____Yes ____No

Water removed from excavation ____Yes ____No

Ramps, Walkways, Bridges over Excavations Equipped with Handrails ____Yes ____No

Shoring System Designed by Professional Engineer ____Yes ____No

Excavations Barricaded or Filled in at End of Day ____Yes ____No

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B

CHEMICAL HAZARD SUMMARY INFORMATION

Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8854

Material Safety Data Sheets Collection:

Sheet No. 5
Chromic Acid and Chromates

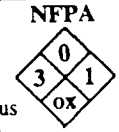
Issued: 10/77 Revision: C, 7/91 Errata: 12/94

Section 1. Material Identification

Chromic Acid (CrO_3) Description: Produced by roasting chromite ore with alkali or lime, leaching with calcium oxide, crystallizing the chromate or dichromate, and then treating it with an excess of sulfuric acid. Used in ceramic glazes, colored glass, dyes, batteries, explosives, water treatment, wood treatment and preservatives, refractories, copper stripping, aluminum anodizing, photomechanical processing, chromium metal plating, purifying oil and acetylene, hardening microscopic preparations, and manufacturing chromated copper arsenate; and as a corrosion inhibitor, a catalyst, an oxidizing agent in organic chemistry, and an etchant for plastics.

R 1
I 4
S 3*
K 0
* Percutaneous (broken skin)

NFPA



HMIS
H 3
F 0
R 1
PPG†
† Sec. 8

Other Designations: CAS No. 1333-82-0; chromic acid; chromic acid, solid (DOT); chromium anhydride; chromium (VI) oxide; chromium trioxide; chromium (6+) trioxide; monochromium trioxide; puratronic chromium trioxide. Chromic acid is the commonly used name, although true chromic acid (CrH_2O_4, CAS No. 7738-94-5) cannot be isolated from solution. Chromic acid and chromates (as CrO_3, CAS No. 7440-47-3).

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Caution: A powerful oxidizer, chromic acid may explode on contact with reducing agents and cause ignition on contact with organic materials. This poison and human carcinogen is corrosive to skin and irritating to mucous membranes. Eye contact may cause permanent blindness.

Section 2. Ingredients and Occupational Exposure Limits

Chromic acid, 99% CrO_3

1990 OSHA PEL
Ceiling: 0.1 mg(CrO_3)/m³

1987 IDLH Level
30 mg/m³

1990-91 ACGIH TLVs
TWA: 0.05 mg(Cr)/m³
Ceiling: 0.1 mg/m³

1990 NIOSH REL
TWA: 0.025 mg(Cr(VI))/m³
Ceiling: 0.05 mg/m³/15 min (Cr(VI))

1985-86 Toxicity Data*
Rat, oral, LD_{50}: 80 mg/kg
Mouse, oral, LD_{50}: 127 mg/kg
Human, inhalation, TC_{Lo}: exposed continuously to 110 µg over 3 years. Toxic effects include tumorigenic (carcinogenic by *RTECS* criteria); sense organs and special senses (olfaction tumors); lungs, thorax, or respiration (tumors).
Dog, subcutaneous, LD_{Lo}: 330 mg/kg

* See NIOSH, *RTECS* (GB6650000), for additional mutative, reproductive, toxicity and tumorigenic data.

Section 3. Physical Data*

Boiling Point: Decomposes at 482 °F (250 °C) to $Cr_2O_3 + O_2$
Melting Point: 385 °F (196 °C)
Molecular Weight: 99.98

Specific Gravity: 2.7
Water Solubility: Soluble
Heat of Fusion: 37.7 cal/g

Appearance and Odor: Dark, purplish-red, prismatic, deliquescent (absorbs all moisture from air) crystals, or a granular powder with no detectable odor.

* These physical data apply only to chromic acid (CAS No. 1333-82-0).

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Chromic acid is noncombustible, but accelerates burning of combustibles (wood, paper, oil). For small fires, *use only water*, not dry chemical, carbon dioxide (CO_2), or halon.

Unusual Fire or Explosion Hazards: A powerful oxidizer, chromic acid ignites on contact with acetic acid and alcohol. It may react rapidly enough with organic materials to cause ignition. Containers may explode if involved in fire.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Cool fire-exposed containers with flooding amounts of water since the decomposing material may form a hot, viscous foam that can cause containers to rupture and explode. *Use caution!* For large fires, flood area from a safe distance, and cool containers from the side with a water spray until after fire is well out. If possible without risk, move containers. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holder. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Chromic acid is generally stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: This material is incompatible with acetic acid, acetic anhydride, acetone, alcohols, alkali metals, ammonia, arsenic, anthracene, benzene, bromine penta fluorine, butyric acid, camphor, chromous sulfide, diethyl ether, glycerol, hydrogen sulfide, methyl alcohol, naphthalene, peroxyformic acid, phosphorus, potassium hexacyanoferrate, pyridine, selenium, sodium, and turpentine. Chromic acid ignites ethyl alcohol and many hydrocarbons.

Conditions to Avoid: Avoid excess heat and contact with combustible or organic materials.

Hazardous Products of Decomposition: Thermal oxidative decomposition of chromic acid can produce carbon dioxide, smoke, and irritating toxic fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC and NTP list chromic acid and other forms of hexavalent (VI) chromium as human carcinogens.

Summary of Risks: Chromic acid is a poison and a powerful irritant to skin, eyes, and respiratory tract. Skin or lung sensitization (allergic reactions) may occur. Exposure can cause dermatitis (skin rash), asthma, pulmonary edema (fluid in lungs), kidney damage, a "chrome hole," or a perforation of the nasal septum (tissue between nostrils).

Medical Conditions Aggravated by Long-Term Exposure: Any chronic lung or skin condition.

Target Organs: Skin, respiratory tract (including nose, throat, airways, and lungs), and kidney.

Primary Entry Routes: Eyes, skin contact, inhalation, and ingestion.

Acute Effects: Inhalation may cause irritation or burning of nose, throat, and air passages, cough, wheezing, and shortness of breath. Higher exposures may cause pulmonary edema (fluid in lungs). Skin exposure may cause dermatitis (skin rash), irritation, burning, itching, redness, and ulceration (skin destruction) which may penetrate. Eye contact can cause irritation, burning, lacrimation (watering), loss of sight and permanent blindness if not removed quickly.

Chronic Effects: Chronic inhalation of excessive levels may cause epistaxis (nosebleed), "chrome holes," nasal congestion, tooth enamel erosion, chest pain, asthma (via allergic sensitization), bronchitis, or respiratory tract cancer. Chronic eye exposure may cause conjunctivitis. Skin contact

Continue on next page

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Section 6. Health Hazard Data, *continued*

can cause irritant or allergic contact dermatitis, or skin ulceration. Chronic systemic absorption could cause liver or kidney damage.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Do not let victim rub eyes or keep them tightly shut. Consult a physician immediately.
Skin: Rinse with flooding amounts of water for at least 15 min, and wash with a gentle soap. Promptly remove contaminated clothing. For redness, blistering, or persistent irritation, consult a physician.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water. *Do not induce vomiting* since this worsens the victim's condition. *Do not* neutralize this acid.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: After decontamination and neutralization, treatment of acid burns is similar to that of thermal burns, although bullae and loose necrotic tissue should be debrided. Update tetanus status. *For severe acid burns,* fluid resuscitation is critical to prevent mortality from hypovolemia and renal failure. Monitor serial vital signs, urine output, electrolytes, blood count, and urinalysis as clinically indicated. Neurovascular compromise distal to a circumferential extremity burn may require escharotomy or fasciotomy. *For inhalation exposures to acids,* a CXR, EKG, ABGs, PFTs, SMA, and CBC may aid in treatment. Evaluate and treat as indicated for reactive airways, upper airway obstruction and noncardiogenic pulmonary edema (possibly delayed onset). Although literature documentation is inadequate, a burst of steroids may help prevent development of sequelae such as reactive airways dysfunction syndrome or bronchilitis obliterans. For ocular exposures to acids, ensure adequate decontamination. Determination of pH may be helpful. A Morgan Lens© and topical anesthesia may aid in irrigation. Perform fluorescein staining and slit lamp evaluation and consult an opthamalogist. Antibiotic ointments, mydriatic/cycloplegics, topical corticosteroids (after epithelial recovery), patching, and possibly anterior chamber paracentesis may be indicated depending on clinical presentation. Acutely and in follow-up, evaluate as indicated for intraocular pressure, lacrimal and lid function, corneal integrity and infection. Urinary chromium is of questionable value.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel and evacuate all unnecessary personnel. Cleanup personnel should protect against dust inhalation and eye contact. Do not handle broken packages unless wearing appropriate personal protective equipment. Keep combustibles (wood, paper, etc.) away from spilled material. Whenever possible, use wet cleanup methods; if not, use vacuum cleanup. Remove spills immediately to prevent dust dispersion. For a water spill, neutralize with agricultural lime, crushed limestone, or sodium bicarbonate. For a land spill, dig a pit, pond, or lagoon to contain material. If time permits, seal these with an impermeable, flexible membrane liner. Dike surface flow with soil, sand or foamed concrete. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Transport: If allowed contact with soil, chromic acid, solid, lowers pH and may leach into water sources, causing an effect similar to acid rain's on water sources. This material's carcinogenicity makes it hazardous to the environment in its hexavalent state.
Environmental Degradation: The recommended disposal means are reduction, precipitation, or ion exchange. Landfill disposal is not recommended since it raises soil acidity.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.22): Corrosive waste
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 10 lb (4.54 kg) [*per Clean Water Act, Sec. 311(b)(4)]†
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Tables Z-1-A and Z-2)
† Chromic acid (CAS No. 7738-94-5) is listed.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For 0.5 mg/m³ concentrations (if not fumes), use any dust and mist respirator except single-use and quarter-mask respirators. For 1.25 mg/m³ concentrations, use any powered air-purifying respirator with a high-efficiency particulate filter. For 2.5 mg/m³ concentrations, use any air-purifying full facepiece respirator with a high-efficiency particulate filter. For 30 mg/m³ concentrations, use any supplied air respirator with a full facepiece and operated in a pressure-demand or other positive-pressure mode. All concentrations may require eye protection. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local ventilation systems to maintain airborne concentrations below occupational exposure levels. Local exhaust ventilation is preferred since it prevents contaminant dispersion into work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Contact lenses may minimize or worsen eye injuries. In some cases, soft lenses can actually protect eyes, not worsen corneal damage, due to strong chemicals. In other cases, chemical entrapment is presumed a possible hazard. Since contact lens use in industry is controversial, establish your own policy. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in glass bottles, cans, or drums. Protect against physical damage. Separate from combustible, organic, or other easily oxidizable materials. Protect from excess moisture which could cause containers to rust. Do not store on wooden floors. Store away from foodstuffs and flammable liquids and solids.
Engineering Controls: Avoid dust inhalation and skin or eye contact. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good housekeeping procedures.
Other Precautions: Institute preplacement and periodic medical exams of exposed workers with attention to the skin and respiratory tract. Consider preplacement and periodic chest radiographs.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Chromic acid, solid
DOT Hazard Class: Oxidizer
ID No.: NA1463
DOT Label: Oxidizer
DOT Packaging Exceptions: 173.153
DOT Packaging Requirements: 173.164

IMO Shipping Name: Chromium trioxide, anhydrous
IMO Hazard Class: 5.1
ID No.: UN1463
IMO Label: Oxidizer, Corrosive
IMDG Packaging Group: II

MSDS Collection **References:** 26, 38, 73, 85, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 139, 140, 143, 142, 145, 148, 159
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 80

THALLIUM METAL
(Revision A)
Issued: December 1980
Revised: April 1988

SECTION 1. MATERIAL IDENTIFICATION

25

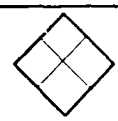
Material Name: THALLIUM METAL

Description (Origin/Uses): Used in semiconductor research; also alloyed with mercury for the manufacture of switches and closures that operate at subzero temperatures.

Other Designations: Tl; NIOSH *RTECS* No. XG3425000; CAS No. 7440-28-0

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

Comments: The hazards of working with thallium metal are associated with cutting, grinding, welding, etc., that produce dust, fumes, powders, and gases.



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HMIS			
H	1		
F	1	R	1
R	1	I	3
PPG*		S	1
*See sect. 8		K	-

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
Thallium Metal, CAS No. 7440-28-0	Ca 100	IDLH* Level: 20 mg/m³ (Soluble Compounds) **OSHA PEL (Skin**)** 8-Hr TWA:*** 0.1 mg/m³ **ACGIH TLV, 1987-88** TLV-TWA:*** 0.1 mg/m³ **Toxicity Data**** Man, Oral, TD_{Lo}: 5.714 mg/kg

*Immediately dangerous to life and health (soluble).
**This material or its salts can be absorbed through intact skin, which contributes to overall exposure.
***Exposure limit defined for soluble thallium compounds as Tl.
****See NIOSH, *RTECS*, for additional data.

SECTION 3. PHYSICAL DATA

Boiling Point: 2655°F (1457°C)
Melting Point: 579°F (304°C)
Specific Gravity (H_2O = 1): 11.85
Water Solubility (%): Insoluble
Molecular Weight: 204 Grams/Mole

Appearance and Odor: A bluish white, very soft, easily fusible heavy metal; odorless.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
*	*	% by Volume	*	*

Extinguishing Media: *Use dry chemical, "alcohol" foam, carbon dioxide, or water spray to put out thallium fires. Contact your supplier for further recommendations.

Unusual Fire or Explosion Hazards: Thallium metal dust particles suspended in the air can explode. If a thallium dust cloud forms, immediately eliminate all possible sources of ignition such as sparks, open flame, etc., and spray the area with a water mist or fog. Working with this material can produce heat and sparks, which can ignite flammable materials and vapors in the workplace.

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 5. REACTIVITY DATA

Thallium metal is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization. In air, a poisonous coating of thallium oxide (Tl_2O) can develop on the exposed surface of thallium metal.

Chemical Incompatibilities: This material reacts violently with fluorine.

Conditions to Avoid: Prevent contact with fluorine. Avoid exposure to sources of ignition such as open flame, sparks, and lighted tobacco products.

Hazardous Products of Decomposition: During fires thallium can form thallium oxide.

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SECTION 6. HEALTH HAZARD INFORMATION

Thallium metal is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: Thallium is a cumulative poison. It or its salts can be absorbed through intact skin; if they are ingested they are rapidly absorbed by the gastrointestinal (GI) tract. Thallium acts as a mitotic (affecting cell division) agent and a general cellular poison. Acute poisoning chiefly affects the central nervous system (CNS) and the GI tract. The ingestion of soluble thallium salts causes more serious effects than the ingestion of the pure metal. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of the CNS, GI tract, kidneys, liver, and eyes may be worsened by exposure to thallium. Administer preplacement and periodic medical exams emphasizing these organs' functions. **Target Organs:** Eyes, CNS, lungs, liver, kidneys, GI tract. **Primary Entry:** Skin absorption or contact, inhalation. **Acute Effects:** Nausea, vomiting, diarrhea, tingling or pain in the extremities, weakness, coma, convulsions, and death. **Chronic Effects:** Weakness, pain in the extremities (polyneuritis); loss of hair (alopecia, the most visible sign); and disorders of the cardiac, renal, and endocrine systems. **FIRST AID: Eyes.** Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. **Skin.** Immediately wash the affected area with soap and water because of the increased hazard from absorption. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. **Ingestion.** *Treat as an emergency.* 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 then induce vomiting.

GET MEDICAL HELP (IN PLANT, PARAMEDIC, COMMUNITY) FOR ALL EXPOSURES. Seek prompt medical assistance for further treatment, observation, and support after first aid. The treatment recommended in Genium reference 100 (p. 529) includes the following: Maintain fluid and electrolytic balance; administer potassium chloride to replace thallium intracellularly; and use hemoperfusion and hemodialysis as warranted by the specifics of the incident. Various chelating therapies have been recommended.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate all nonessential personnel, and provide adequate ventilation. Cleanup personnel need protection against contact with and inhalation of dust (see sect. 8). Prevent skin contact. Scoop up spilled thallium into suitable containers for disposal. Carefully sweep or vacuum up small spills or residues without creating dust.

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

OSHA Designations

Air Contaminant (29 CFR 1910.1000 Subpart Z, for soluble thallium compounds as Tl)

EPA Designations (40 CFR 302.4)

RCRA Hazardous Waste: Listed without Number

CERCLA Hazardous Substance, Reportable Quantity: 1000 lbs (454 kg)

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. 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: Wear impervious gloves; boots; aprons; and clean, impervious, body-covering clothing to prevent any possibility of skin contact. Barrier creams may be useful to limit the effects of skin contact.

Ventilation: Install and operate general and local ventilation systems powerful enough to maintain airborne levels of thallium 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. Particles can adhere to contact lenses and cause corneal damage. Do *not* wear contact lenses in any work area.

Comments: Practice good personal hygiene; always wash thoroughly after using this material. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store thallium metal in a cool, dry, well-ventilated area in closed containers away from oxidizing agents, fluorine, and sources of ignition.

Special Handling/Storage: Practice good housekeeping techniques that minimize accumulation of dust; cleaning procedures should not create dusty conditions.

Transportation Data (49 CFR 172.101-2):

DOT Shipping Name: Thallium Salt, Solid, NOS **DOT Label:** Poison **IMO Label:** Poison or St. Andrew's Cross (X)*

DOT ID Nos. UN1707; NA1707 **DOT CLass:** Poison B **IMO Class:** 6.1

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

References: 1, 2, 12, 73, 84-94, 100, 103.

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GENIUM PUBLISHING CORP.

No. 82

COBALT METAL/POWDER
(Revision A)
Issued: March 1981
Revised: April 1988

SECTION 1. MATERIAL IDENTIFICATION

25

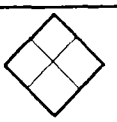
Material Name: COBALT METAL/POWDER

Description (Origin/Uses): Used in alloys and in nuclear weapons.

Other Designations: Co; NIOSH *RTECS* No. GF8750000; CAS No. 7440-48-4

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

Comments: The hazards of working with cobalt metal/powder are associated with cutting, grinding, welding, etc., that produce dust, fumes, powders, and gases.



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HMIS	
H	1
F	1
R	1
PPG*	
*See sect. 8	
R	1
I	4
S	1
K	-

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
Cobalt Metal/Powder, CAS No. 7440-48-4	Ca 100	IDLH* Level: 20 mg/m³ **OSHA PEL** 8-Hr TWA: 0.1 mg/m³ **ACGIH TLVs, 1987-88** TLV-TWA: 0.05 mg/m³ TLV-STEL: 0.1 mg/m³ **Toxicity Data**** Rat, Oral, LD_{Lo}: 1500 mg/kg

All the exposure limits above are defined for cobalt metal, dust, and fume as Co.
*Immediately dangerous to life and health.
**See NIOSH, *RTECS*, for additional data with references to tumorigenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: Ca 5792°F (3200°C)
Melting Point: 2719°F (1493°C)
Specific Gravity (H_2O = 1): 8.92

Water Solubility (%): Insoluble
Molecular Weight: 59 Grams/Mole

Appearance and Odor: A gray, hard, magnetic, ductile, and somewhat malleable metal or black powder; odorless.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
*	*	% by Volume	*	*

Extinguishing Media: *Do not use water. Recommended extinguishing agents include dry sand, dry dolomite, dry graphite powder, or sodium chloride. Solid cobalt does not burn; however, its dust can burn and it may form explosive mixtures with air.
Unusual Fire or Explosion Hazards: Cobalt dust particles suspended in the air can explode. If a cobalt dust cloud does form, immediately eliminate all possible sources of ignition such as sparks, open flame, etc., and take appropriate precautions (e.g., spray the affected area with a water mist or fog). Pyrophoric cobalt, which appears as a black powder, burns brilliantly when exposed to air. Working with this material can produce heat and sparks, which can ignite flammable materials and vapors in the workplace.
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 5. REACTIVITY DATA

Cobalt metal/powder is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization.

Chemical Incompatibilities: Pyrophoric cobalt decomposes cold acetylene and becomes incandescent. Fused ammonium nitrate can sometimes react explosively with powdered cobalt.

Conditions to Avoid: Prevent contact with incompatible chemicals. Powdered cobalt is more reactive than the solid metal; do not allow the powder to accumulate or form a potentially explosive dust cloud.

Hazardous Products of Decomposition: Only powdered cobalt can burn; various oxides of cobalt may be produced during fires.

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SECTION 6. HEALTH HAZARD INFORMATION

Cobalt metal/powder is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: Inhalation of cobalt dust can cause pulmonary symptoms such as wheezing, irritation of the upper respiratory tract (URT), and hypersensitivity reactions (asthma). Skin contact with powdered cobalt may cause dermatitis, especially in the creases of the elbows, knees, ankles, and neck. Contact with eyes may cause conjunctivitis. Ingestion may produce a hot sensation along with vomiting, diarrhea, and nausea. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of the skin and the URT may be worsened by exposure to cobalt; administer preplacement and periodic medical exams emphasizing these functions.

Target Organs: Respiratory system, skin, bladder, kidneys, and eyes. **Primary Entry:** Skin contact, inhalation.

Acute Effects: Contact dermatitis and breathing difficulties. **Chronic Effects:** Allergic asthma, restricted pulmonary functions, and interstitial fibrosis may be caused by long-term occupational exposure to cobalt or its compounds.

FIRST AID

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

Skin: 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 cobalt salts are ingested, give 1 to 2 glasses of water and induce vomiting.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate all nonessential personnel, remove all sources of heat and ignition, and provide adequate ventilation. Cleanup personnel need protection against contact with and inhalation of dust (see sect. 8). Prevent skin contact. Scoop up spilled cobalt into suitable containers for disposal. Carefully sweep or vacuum up small spills or residues without creating dust.

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

OSHA Designations

Air Contaminant (29 CFR 1910.1000 Subpart Z, for cobalt metal, dust, and fume)

EPA Designations (40 CFR 302.4)

RCRA Hazardous Waste: Not Listed

CERCLA Hazardous Substance: Not Listed

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. 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: Wear impervious gloves; boots; aprons; and clean, impervious body-covering clothing to prevent any possibility of skin contact. Barrier creams may be useful to limit the effects of skin contact. **Ventilation:** Install and operate general and local ventilation systems powerful enough to maintain airborne levels of cobalt metal, dust, or fume 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. Particles can adhere to contact lenses and cause corneal damage. Do *not* wear contact lenses in any work area.

Comments: Practice good personal hygiene; always wash thoroughly after using this material. 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 dust or create dusty working conditions.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store cobalt metal/powder in a cool, dry, well-ventilated area in closed containers away from oxidizing agents, incompatible chemicals (see sect. 5), and sources of heat or ignition.

Special Handling/Storage: Practice good housekeeping techniques that minimize accumulation of dust; cleaning procedures should not create dusty conditions.

Transportation Data (49 CFR 172.101-2): Not Listed

References: 1, 2, 12, 73, 84-94, 100, 103.

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Material Safety Data Sheets Collection:

Sheet No. 83
Chromium Metal/Powder

Issued: 3/81 Revision: A, 11/89

Section 1. Material Identification

30

Chromium Metal/Powder Description: Obtained from chrome ore, chromite ($FeCr_2O_4$), by electrolysis of chromium solutions, by direct reduction (ferrochrome), and by reducing the oxide with finely divided carbon or aluminum. Used for chromeplating other metals; for greatly increasing metal resistance and durability; in manufacturing chrome-steel or chrome-nickel-steel alloys (stainless steel); as a constituent of inorganic pigments; as protective coating for automotive and equipment accessories; and in nuclear and high-temperature research.

Other Designations: Chrome; Cr; CAS No. 7440-47-3.

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

R 1
I 4
S 1
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PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Chromium metal/powder, ca 100%

OSHA PEL	ACGIH TLV, 1988-89*	NIOSH REL, 1987†	Toxicity Data‡
8-hr TWA: 1 mg/m³	TLV-TWA: 0.5 mg/m³	8-hr TWA (for chromium metal and insoluble salts): 1 mg Cr/m³	Rat, implant, TD_{Lo}: 1200 µg/kg body weight administered intermittently over six weeks

* This TLV is applicable to Cr^{+2} and Cr^{+3} compounds. For water soluble and water-insoluble Cr^{+6}, the 8-hr TWA is 0.05 mg Cr $^{+6}$/m³. Certain water-insoluble Cr^{+6} compounds (zinc chromate, calcium chromate, lead chromate, barium chromate, strontium chromate, and sintered chromium trioxide) are designated as A1a (human carcinogen).

† The NIOSH REL (10-hr TWA) for carcinogen Cr^{+6} compounds is 1 µg/m³; for noncarcinogenic Cr^{+6} compounds (including chromic acid), the RELs (10-hr TWAs) are 25 µg/m³ and 50 µg/m³ (15-min ceiling). The noncarcinogenic compounds include mono- and dichromates of hydrogen, cesium, sodium, lithium, potassium, rubidium, ammonia, and Cr^{+6} (chromic acid anhydride). Any and all Cr^{+6} materials excluded from the noncarcinogenic group above are carcinogenic Cr^{+6} compounds.

‡ See NIOSH, *RTECS* (GB4200000), for additional data with references to tumorigenic effects.

Section 3. Physical Data

Boiling Point: 4788 °F (2642 °C)
Melting Point: 3452 °F (1900 °C)
Vapor Pressure: 1 mm Hg at 2941 °F (1616 °C)
Vapor Density (Air = 1): 1.79

Atomic Weight: 51.996 g/mol
Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 7.2 at 68 °F (20 °C)
Water Solubility: Insoluble

Appearance and Odor: Steel-gray, lustrous metal; no odor.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: Cloud, 1076 °F (580 °C); dust layer, 752 °F (400 °C)	LEL: Dust cloud explosion, 0.230 oz/ft³	UEL: None reported

Extinguishing Media: Use dry chemical or sand.

Unusual Fire or Explosion Hazards: Particle size and dispersion in air determine reactivity. Chromium powder explodes spontaneously in air, while chromium dust suspended in CO_2 is ignitable and explosive when heated.

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

*One hundred percent of dust goes through a 74-µm sieve. A 140-mJ spark can ignite a dust cloud.

Section 5. Reactivity Data

Stability/Polymerization: Chromium is stable when properly handled and stored. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Chromium reacts readily with dilute, not nitric, acids to form chromous salts. It is soluble in acids (not nitric) and strong alkalis. Its powder is incompatible with strong oxidizing agents, including high O_2 concentration. Evaporation of mercury (Hg) from Cr amalgam leaves pyrophoric chromium. Finely divided Cr attains incandescence with nitrogen oxide, potassium chlorate, and sulfur dioxide. Molten lithium at 18 °C severely attacks Cr. Fused ammonium nitrate below 200 °C reacts explosively and may ignite or react violently with bromine pentafluoride.

Hazardous Products of Decomposition: Thermal oxidative decomposition of Cr can produce toxic chromium oxide fumes.

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Section 6. Health Hazard Data

Carcinogenicity: The NTP and OSHA list chromium as a human carcinogen.

Summary of Risks: When ingested chromium is a human poison, with gastrointestinal (GI) effects. Chromium 3 (Cr^{+3}) compounds show little or no toxicity. Less soluble chromium 6 (Cr^{+6}) compounds are suspected carcinogens and severe irritants of the larynx, nasopharynx, lungs, and skin (Sec. 2). Chromic acid or chromate salts cause irritation of the skin and respiratory passage. Ingestion leads to severe irritation of the gastrointestinal tract, renal damage, and circulatory shock. Chromium metal (when heated to high temperatures) and insoluble salts are said to be involved in histological fibrosis of the lungs, which may progress to clinically evident pneumoconiosis. Exposure to chromate dust and powder can cause skin (dermatitis) and eye irritation (conjunctivitis).

Medical Conditions Aggravated by Long-Term Exposure: An increased incidence of bronchogenic carcinoma occurs in workers exposed to chromate dust.

Target Organs: Respiratory system.

Primary Entry: Inhalation, percutaneous absorption, and ingestion.

Acute Effects: Acute exposures to dust may cause headache, coughing, shortness of breath, pneumoconiosis, fever, weight loss, nasal irritation, inflammation of the conjunctiva, and dermatitis.

Chronic Effects: Asthmatic bronchitis.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: Brush off chromium dust. After rinsing affected area with flooding amounts of water, wash it with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that conscious person slowly drink 1 to 2 glasses of water to dilute. Do not induce vomiting. A physician should evaluate all ingestion cases.

After first aid, get appropriate in-plant, paramedic, or community medical attention and support.

Physician's Note: Acute toxicity causes a two-phase insult: 1) multisystem shock due to gastrointestinal corrosivity and 2) hepatic, renal, hematopoetic insult. Treatment should use ascorbic acid as a neutralizer with gastric lavage. If the ingestion is substantial, exchange transfusions and/or consider hemodialysis. Treat allergic dermatitis with local cortisone or 10% ascorbic acid to reduce Cr^{+6} to Cr^{+3}. Ten percent EDTA in a lanolin base applied every 24 hr helps heal skin ulcers.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of large spills. Cleanup personnel should wear protective clothing and approved respirators. Remove heat and ignition sources. Provide adequate ventilation. Keep airborne dust at a minimum. Remove spills quickly and place in appropriate containers for disposal or reuse.

Disposal: Reclaim salvageable metal. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per Clean Water Act, Sec. 307(a)]

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Wear a NIOSH-approved respirator if necessary. Wear an SCBA with a full facepiece when the particle concentration's upper limit is 50 mg/m^3.

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

Other: Wear impervious rubber gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA standard (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 103).

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Launder contaminated clothing before wearing. Remove this material from your shoes and equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store material in cool, dry, well-ventilated area separate from acids and oxidizing agents. Seal and protect containers from physical damage. Keep away from heat or ignition sources.

Engineering Controls: Avoid dust inhalation. Practice good housekeeping (vacuuming and wet sweeping) to minimize airborne particulates and to prevent dust accumulation. Use nonsparking tools and ground electrical equipment and machinery.

Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection **References:** 1, 2, 26, 38, 80, 87, 88, 89, 100, 109, 124, 126

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

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Material Safety Data Sheets Collection:

Sheet No. 100
Aluminum Metal/Powder

Issued: 12/81 Revision: B, 4/90

Section 1. Material Identification

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Aluminum Metal/Powder Description: The primary sources of aluminum are the ores cryolite and bauxite. Produced by electrolysis of bauxite in a bath of molten cryolite, or made synthetically from fluorspar. As pure metal or as alloys, aluminum is used for aircraft, building and construction materials, die-cast auto parts, highway products, permanent magnets, photoengraving plates, corrosion-resistant chemical equipment, machinery and accessory equipment, and electrical conductors; tubes for ointments, toothpaste, and shaving cream; containers and flexible packaging; in dental alloys, manufacturing printing inks; testing for gold, arsenic, and mercury; the jewelry industry; as reducers for determining nitrates and nitrites; for precipitating copper and coagulating colloidal solutions of arsenic or antimony; and in the manufacture of aluminum powder for aluminum paints, explosives, fireworks, flashlights in photography, and for absorbing occluded gases in the manufacture of steel.
Other Designations: CAS No. 7429-90-5; Al; alumina fibre; aluminum flake; aluminum dehydrated; metana aluminum paste.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

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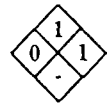
S 2
K 1

NFPA



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* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Aluminum metal/powder, ca 100%*

OSHA PELs
8-hr TWA: 5 mg/m³ (respirable fraction, pyro powders, welding fumes)
8-hr TWA: 15 mg/m³ (total dust)

ACGIH TLVs, 1989-90
TLV-TWA: 5 mg/m³ (pyro powders, welding fumes)
TLV-TWA: 10 mg/m³ (metal dust)

NIOSH REL, 1987
None established
Toxicity Data†
None reported

* *Since commercially "pure" Al may contain up to 1% iron (Fe), silicon (Si), and copper (Cu), exposure may also be to a mixture of these and other materials.*
† *Monitor NIOSH, RTECS (BD0330000), for future toxicity data.*

Section 3. Physical Data

Boiling Point: 4221 °F/2327 °C
Melting Point: 1220 °F/660 °C
Vapor Pressure: 1 mm Hg at 2343 °F/1284 °C
Molecular Weight: 26.98 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 2.70
Water Solubility: Insoluble in hot and cold water

Appearance and Odor: Silvery-white, metallic solid, foil, particulate. No odor.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** 1202 °F/650 °C (cloud); 1440 °F/760 °C (dust layer)*	**LEL:** >0.04 oz/ft³	**UEL:** None reported

Extinguishing Media: If possible, isolate and permit large fires to burn out while controlling smaller fires with sand, talc, or sodium chloride. Use nonsparking tools to ring small fires. *Do not use water, carbon tetrachloride (CCl_4), or halon!* A mixture of aluminum powder and water slowly forms hydrogen that can be hazardous if confined.
Unusual Fire or Explosion Hazards: Bulk aluminum is not combustible, but powdered aluminum can be a severe fire and explosion hazard when exposed to heat and ignition sources or by chemical reaction with powerful oxidizers. Aluminum forms explosive mixtures in air. When bulk dust is damp, it may heat spontaneously. Particles size, coating, and dispersion in air determine reactivity. The hazard increases with fineness.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Evacuate all unnecessary personnel upwind and isolate hazard area. Prevent dust clouds and eliminate drafts. Cool exposed containers with water, but be careful not to get water inside container. Be aware of runoff from fire control methods. Runoff to sewers may cause fire, explosion hazard, or pollution. Do not release to sewers or waterways.

* One hundred percent of dust goes through a 44-μm sieve. A 0.05-J spark can ignite an Al dust cloud.

Section 5. Reactivity Data

Stability/Polymerization: Stable at room temperature in closed containers under normal storage and handling conditions, aluminum corrodes rapidly in contact with other metals since it is strongly electropositive. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Aluminum is incompatible with perchlorate/nitrate/water mixtures, powdered silver chloride, ammonium peroxodisulfate + water, peroxides, halocarbons, halogens, acids, hydrogen chloride gas, molten silicon steels, phosphorus, sulfur, selenium, interhalogens, oxidants, perchlorate salts, and chlorates. Potentially explosive reaction with carbon tetrachloride during ball milling operations with chloroform amidinium nitrate, and sodium acetylide. Violent or explosive 'thermite' reaction when heated with metal oxides, oxosalts (nitrates, sulfates), or sulfides; hot copper oxide worked with an iron or steel tool; or with antimony, arsenic, and anitmony trichloride vapor. An explosive reaction (above 1472 °F/600 °C) of Al with iron powder + water releases explosive hydrogen gas; interaction with sodium hydroxide also releases explosive hydrogen gas; and a violent exothermic reaction occurs above (1112 °F/600 °C) with sodium diuranate. Al reacts with diborane to form a pyrophoric product. Bulk Al may undergo dangerous interactions with alcohols. Reaction with arseneic trioxide + sodium arsenate + sodium hydroxide produces the toxic arsine gas.
Hazardous Products of Decomposition: Inhalation of metallic oxide smoke (Al_2O_3) at 15 mg/m³ or greater can cause "metal fume fever."

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists aluminum as a carcinogen.
Summary of Risks: Its powder and dust are the most dangerous forms. Most hazardous exposures to aluminum occur in refining and smelting processes. Aluminum dust is a respiratory and eye irritant. Lung fibrosis is reported in aluminum welders and polishers, aluminum smelting (potroom) workers, and in workers involved in manufacturing alumina abrasives or explosives from stamped aluminum powders. A single case was reported of fibrosis occuring with encephalopathy (alterations of the brain's structure) after 13.5 years of working with fine powder. Death resulted from bronchopneumonia following progressive encephalopathy. Particles of aluminum deposited in the eye may cause necrosis (localized tissue death) of the cornea. Repeated aluminum contact with skin has been associated with skin telangiectases (bleeding into the tissues and mucous surfaces because of the abnormal fragility and dilatation of the capillary vessels and arterioles), delayed hypersensitivity, and granulomas. Acroanesthesia (numbness of the fingers) is reported in cotton mill operations where there is long contact with wet Al during bobbin winding. Mortality analysis of Al production workers showed malignant tumors of the nervous system, cancer of the pancreas, bronchus, and lung, and leukemia, especially in potroom workers.
Medical Conditions Aggravated by Long -Term Exposure: Symptoms of long-term overexposure are weakness, cough, and shortness of breath with generalized interstitial fibrosis and emphysema.
Target Organs: Respiratory tract, eyes, skin.
Primary Entry Routes: Inhalation, ingestion.
Acute Effects: Signs and symptoms of inhalation of aluminum powder or dust are dyspnea, cough, lethargy, anorexia, and an increased respiration rate.
Chronic Effects: Chronic inhalation of aluminum dust is associated with pulmonary fibrosis, asthma, emphysema, dyspnea, cough, and chronic obstructive lung disease.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water. For cuts, abrasive irritation or thermal burns, get medical attention.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Since aluminum is poorly absorbed through the gastrointestinal tract, vomiting is seldom necessary. However, if large amounts of aluminum are ingested, contact a physician.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Chronic exposure may lead to fibrosis with large bleb formation and risk of spontaneous pnuemothorax.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice an aluminum powder spill control and countermeasure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel upwind and remove all heat and ignition sources. Cleanup personnel must use protection against airborne dust and threat of fire. Promptly clean spill using conductive, nonsparking scoops and soft brushes with natural bristles. Use approved, grounded vacuum cleaners only in final cleanup. Place powder in closed, pressure-vented, dry, metal containers. Mix dry sand with scrap and tightly seal. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Use tight-weave, nonstatic generating, protective clothing (no metallic fasteners, cuffs, or pockets) and nonsparking safety shoes when working with Al powder. Special protective clothing is needed to work with hot or molten aluminum.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PELs and ACGIH TLVs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Launder contaminated clothing before wearing. Remove this material from your shoes and equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in sealed containers in a dry, low fire risk area away from all heat and ignition sources, oxidizing agents, combustibles, acids, alkalis, halogens, carbon disulfide, halogenated hydrocarbons, and all other incompatible materials (Sec. 5). Protect containers from physical damage; exclude moisture and humid air.
Engineering Controls: Avoid generation of airborne dust. Use good housekeeping to prevent dust accumulation. Electrically ground and bond all equipment used with aluminum metal powder. Give preemployment and periodic medical examinations, with particular emphasis on the skin, eyes, and lungs.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Aluminum metallic, powder
DOT Hazard Class: Flammable solid
ID No.: UN1396
DOT Label: Flammable solid
DOT Packaging Requirements: 173.232
DOT Packaging Exceptions: 173.232

MSDS Collection **References:** 2, 4-11, 14-20, 26, 37, 38, 41, 73, 84, 85, 87, 89, 100, 103, 109, 124, 126, 127, 133
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD
F2

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Material Safety Data Sheets Collection:

Sheet No. 124
Vanadium Metal/Powder

Issued: 10/83 Revision: A, 11/90

Section 1. Material Identification

33

Vanadium Metal/Powder (V) Description: Occurs ubiquitously in the earth's crust. Its principle ores are patronite, roscoelite, carnolite, and vanadinite. There are more than 65 different vanadium-containing ores. Also found in crude petroleum, in flue-gas deposits from oil-fired furnaces, or in slags from ferrovanadium production. Vanadium production includes roasting ores and electrolytic refining using a molten salt electrolyte containing vanadium chloride. Used to manufacture rust-resistant vanadium steel, alloy steels, vanadium compounds; as a target material for x-rays; and as a catalyst for sulfuric acid and synthetic rubber.

Other Designations: CAS No. 7440-62-2

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

Cautions: Vanadium is a primary irritant of the mucous membranes of the respiratory tract and the conjunctiva (eye).

R	0
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K	0

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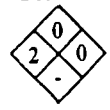

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PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Vanadium, ca 100%

1989 OSHA PEL
Vanadium, as V_2O_5, Respirable Dust and Fume
8-hr TWA: 0.05 mg/m³

1990-91 ACGIH TLV
Vanadium, as V_2O_5, Respirable Dust and Fume
TWA: 0.05 mg/m³

1985-86 Toxicity Data*
Human, inhalation, TD_{Lo}: 4 µg/kg; affected the lungs, thorax, or respiration (sputum, cough); and sense organs and special senses (changes in circulation)

1987 IDLH Level
Vanadium Pentoxide Dust or Fume (as V)
70 mg/m³

1988 NIOSH REL
Vanadium, as V_2O_5, Respirable Dust and Fume
15-min Ceiling: 0.05 mg/m³

* Monitor NIOSH, *RTECS* (YW1630000), for future toxicity data.

Section 3. Physical Data

Boiling Point: 6116 °F (3380 °C)
Melting Point: 3434 + 10 °F (1890 + 10 °C)
Vapor Pressure: 1.5 mm Hg at 4172 °F (2300 °C)
Atomic Weight: 50.92
Specific Gravity: 5.96
Water Solubility: Insoluble in hot or cold water

Appearance and Odor: Light gray powder or white, lustrous bulk solid; no odor.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature:* layer 914 °F (490 °C), cloud 932 °F (500 °C)	LEL: 0.22 oz/ft³*	UEL: None reported

Extinguishing Media: Use dry chemical powder or CO_2 to extinguish a metal fire.

Unusual Fire or Explosion Hazards: Very hot vanadium can burn in air. When dispersed in air as dust, it can be exploded by an ignition source.* However, it has a low explosibility index (0.1) and low ignition sensitivity (0.3) on a scale of 10.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective gear. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

* Vanadium metal dust whose particle size is 100% below 75 µm. Reported minimum ignition energy is 60 mJ for dust cloud.

Section 5. Reactivity Data

Stability/Polymerization: Vanadium is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Massive metal is relatively inert to O_2, N_2, H_2, and H_2O at ambient conditions, but vanadium reacts when heated, and still more readily if powdered. When heated in air, vanadium oxidizes to brownish-black trioxide, blue-black tetroxide or yellow-red pentoxide, depending on temperature.

Chemical Incompatibilities: Vanadium is incompatible with bromine trifluoride, chlorine, nitryl fluoride, lithium, and oxidants. Some samples of vanadium prepared by magnesium reduction of vanadium dichloride or vanadium trichloride are pyrophoric (ignite spontaneously).

Conditions to Avoid: Avoid creating airborne dusty conditions.

Hazardous Products of Decomposition: Thermal oxidative decomposition of vanadium can produce toxic fumes of vanadium oxides (VO_x).

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Section 6. Hazard Data

Carcinogenicity: The NTP, IARC, and OSHA do not list vanadium metal powder as a carcinogen.
Summary of Risks: Elemental vanadium is considered relatively nontoxic and the risks noted in mining operations are usually limited. However, toxic vanadium compounds form easily with the addtion of heat, and may be present in many occupational settings. Vanadium compounds are very irritating to mucous membranes including the respiratory tract. Although no specific lesions are noted, inflammation of all portions of the airways, as well as pulmonary edema, pneumonia, and emphysema are described. The presence of vanadium compounds in areas where residue from the burning of fuel oil may accumulate presents particular problems with unrecognized risk.
Medical Conditions Aggravated by Long-Term Exposure: No permanent effects are reported, but respiratory symptoms may persist for years.
Target Organs: Respiratory system, skin, and eyes.
Primary Entry Routes: Inhalation, ingestion.
Acute Effects: *Skin*: eczema-like reaction with intense itching. Sensitization or generalized hives may occur. Green discoloration of the hands and groin area is noted. *Eyes*: severe irritation with burning and tearing may occur. *Airway*: nasal congestion, throat irritation, dry mouth, green discoloration of the tongue, metallic taste, coughing, bronchitis, pneumonia, chest pain, and pulmonary edema are noted. *Cardiovascular*: constriction of blood supply to the lungs, spleen, kidneys, and intestines. *CNS*: headaches, decreased constriction mentation in severe exposures. *GI*: diarrhea, black stools, cramping.
Chronic Effects: The lung effects may last up to two weeks following exposure. Skin and tongue discoloration may develop gradually.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Notes to Physician: Include diagnostic tests such as vanadium in urine (normal <1 µg/g creatine), patch (eczema), and pulmonary function (FEV_1 and FVC).

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel and provide adequate ventilation. Cleanup personnel should protect against dust inhalation and skin or eye contact. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For concentrations less than or equal to 70 mg/m^3, use a powered air-purifying respirator with full facepiece and high-efficiency particulate filter. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks) or concentrations >70 mg/m^3, wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact.
Ventilation: Provide general and local ventilation systems to maintain airborne concentrations just below the exposure limits (Sec. 2). Exhaust ventilation systems discharging to outside air must conform with applicable local, state, and federal air pollution regulations. Ventilation systems need to be cleaned and their effectiveness tested with airflow measurements taken at least every 3 months. Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry, well-ventilated area. Protect containers from damage. Use good housekeeping practices to prevent accumulation of dust and follow cleaning techniques that minimize airborne particulate.
Engineering Controls: Avoid dust, vapor, or fume inhalation when generated. Prevent contact with eyes and skin. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide preplacement and periodical medical examinations that emphasize the eyes, skin, and lungs. For biological monitoring of exposed workers use urinary vanadium excretion. Include pulmonary function tests in periodical medical examinations.
Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection **References:** 2-10, 12, 14, 20, 26, 40, 41, 73, 84, 88, 89, 100, 101, 103, 109, 124, 126, 127, 132, 133, 136, 138, 139, 140, 143, 146
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheet

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No. 136

SELENIUM

Issued: April 1988

SECTION 1. MATERIAL IDENTIFICATION

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Material Name: SELENIUM

Description (Origin/Uses): Used to manufacture other selenium compounds; also used in photography and xerography and as a catalyst and pigment.

Other Designations: Elemental Selenium; Selenium Base; Selenium Dust; Selenium Metal; Selenium Metal Powder; Se; NIOSH *RTECS* No. VS7700000; CAS No. 7782-49-2

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

Comments: See Genium Industrial MSDS 152 (Selenium Dioxide).

HMIS	
H	3
F	0
R	1
PPG*	
*See sect. 8	
R	1
I	4
S	2
K	0

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
Selenium, CAS No. 7782-49-2	ca 100	IDLH* Level: 100 mg/m³ **OSHA PEL**** 8-Hr TWA: 0.2 mg/m³ **ACGIH TLV,** 1987-88** TLV-TWA: 0.2 mg/m³ **Toxicity Data***** Rat, Oral, LD_{50}: 6700 mg/kg Rat, Inhalation, LD_{Lo}: 33 mg/kg (8 Hrs)

*Immediately dangerous to life and health
**This exposure limit is defined for selenium compounds as Se.
***See NIOSH, *RTECS*, for additional data with references to reproductive, mutagenic, and tumorigenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: ca 1263°F (684°C)
Water Solubility: Insoluble
Melting Point: ca 644°F (340°C)

Specific Gravity (H_2O = 1): Both amorphous and crystalline forms have specific gravities between 4 and 5.
Molecular Weight: 79 Grams/Mole

Appearance and Odor: A dark red to bluish black amorphous solid or dark red, grey, or black crystals appearing in two distinct forms, or allotropes, because of differences in crystalline structures; odorless.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
*	*	% by Volume	*	*

Extinguishing Media: *Selenium does not burn. Use agents such as dry chemical, "alcohol" foam, or carbon dioxide that will extinguish the surrounding fire.

Unusual Fire or Explosion Hazards: None.

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 5. REACTIVITY DATA

Selenium is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization.

Chemical Incompatibilities: This material reacts dangerously with carbides, fluorine, oxygen, potassium, and many more materials (see Genium ref. 84).

Conditions to Avoid: Avoid direct contact with incompatible chemicals to prevent dangerous and violent reactions. Avoid the unintended contact of water with selenium in storage areas or reactor vessels.

Hazardous Products of Decomposition: When heated to decomposition, selenium readily emits toxic oxides of selenium (SeO_x). Selenium itself is a highly toxic and dangerous material.

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SECTION 6. HEALTH HAZARD INFORMATION

Selenium is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: Direct exposure to selenium or inhalation of its dust causes severe irritation of the skin, eyes, and the upper respiratory tract (URT). **Caution:** Some symptoms of exposure to selenium (e.g., chemical pneumonia) may be delayed for several hours. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** URT, skin, eyes. **Primary Entry:** Inhalation, skin contact. **Acute Effects:** Skin and eye burns, contact dermatitis, intense irritation of the URT, and headache. Cases with flulike symptoms resembling metal-fume fever within 24 hours of exposure have been reported. **Chronic Effects:** Odor of garlic on breath; fatigue; irritability; URT irritation; pallor; gastrointestinal distress; metallic taste; and an allergic eye reaction with red, sometimes puffy, eyelids.

FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water. **Skin.** Immediately wash the affected area with plenty of running water. Any worker who develops a rash or contact dermatitis must get medical attention and prevent any further contact with selenium metal or its compounds (e.g., selenium dioxide; see Genium Industrial MSDS 152). **Inhalation.** Remove exposed person to fresh air; restore and/or support his or her breathing as needed. Prompt administration of oxygen gas (O_2) by trained medical personnel may aid recovery. **Ingestion.** Give exposed person several glasses of water to dilute material. Do not induce vomiting. Never give anything by mouth to someone who is unconscious or convulsing.

Treat each exposure to selenium as an emergency! GET MEDICAL HELP (IN PLANT, PARAMEDIC, COMMUNITY) FOR ALL EXPOSURES. Seek prompt medical assistance for further treatment, observation, and support after first aid. If chelation therapy to remove the metallic selenium is indicated, calcium disodium edetate ($CaNa_2$-EDTA) is the chelating agent of choice; do *not* use dimercaprol. Burns may require treatment with 10% sodium thiosulfate cream.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate all nonessential personnel, provide adequate ventilation, and do not add any water to the spill or leak area. Cleanup personnel need protection against contact with and inhalation of dust (see sect. 8). Scoop up spilled selenium into suitable containers for disposal. Carefully sweep or vacuum up small spills or residues without creating dust.

Waste Disposal: Contact your supplier or a licensed contractor for detailed recommendations for disposal. 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: Listed without a Number

CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg)

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Follow the eye- and face-protection guidelines in 29 CFR 1910.133. **Respirator:** Use 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:** Wear impervious gloves; boots; aprons; and clean, impervious, body-covering clothing to prevent any possibility of skin contact. **Ventilation:** Install and operate general and local maximum explosion-proof ventilation systems powerful enough to maintain airborne levels of selenium below the OSHA PEL standard cited in section 2. **Safety Stations:** Make eyewash stations, washing facilities, and safety showers available in areas of use and handling. Make the 10% sodium thiosulfate solution or cream and the $CaNa_2$-EDTA chelating agent formula (sect. 6) readily available to a trained safety specialist. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Particles can adhere to contact lenses and cause corneal damage. Do *not* wear contact lenses in any work area.

Comments: Practice good personal hygiene; always wash thoroughly after using this material. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store selenium in a cool, dry, well-ventilated area in tightly closed containers away from oxidizing agents, organic materials, water, metals, and incompatible chemicals (see sect. 5). **Special Handling/Storage:** Prevent moisture or water contamination in any storage facility. Consider installing an automatic monitoring system to detect selenium contamination; storage under an inert gas (e.g., a nitrogen blanket) may be warranted depending on the work environment. **Engineering Controls:** Use selenium in closed engineering systems because of its significant health and physical hazards (see sects. 4, 5, and 6). All engineering systems (production, transportation, etc.) should be of maximum explosion-proof design (i.e., they must be nonsparking, electrically grounded and bonded, etc.). **Comments:** Perform all work with selenium with a sustained, conscientious effort to prevent accidental contact with water. Do not create a dusty working environment. Develop a sustained, conscientious program of working guidelines prior to any accidental exposure.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Selenium Metal Powder **DOT Label:** Poison **IMO Label:** St. Andrew's Cross (X)*

DOT Class: Poison B **DOT ID No.** UN2658 **IMO Class:** 6.1

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

References: 1, 2, 12, 73, 84-94, 100, 103.

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Material Safety Data Sheets Collection:

Sheet No. 148
Manganese Metal/Powder

Issued: 9/85 Revision: A, 11/89

Section 1. Material Identification

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Manganese Metal/Powder Description: A metallic element associated with iron ores such as pyrolusite, manganite, psilomelane, and rhodochrosite found mainly in open-hearth slags. Manganese is obtained from the reduction of the oxide with aluminum or carbon. Pure manganese is obtained electrically from chloride or sulfate solution. Used in ferroalloys (steel manufacture); for wagon buffers, rock crushers, railway points and crossings; as a purifying and scavenging agent in metal production; in the manufacture of aluminum by Toth process, dry-cell batteries, glass, welding rods, inks, rubber and wood preservatives, paints, and ceramics; high-purity salt for various chemical uses.
Other Designations: Manganese; colloidal manganese; magnacat; Mn; CAS No. 7439-96-5.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

R 1
I 3
S 1
K -

Genium

HMIS
H 3
F 2
R 1
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Manganese, ca 100%

OSHA PEL
Ceiling limit: 5 mg/m³ (manganese compounds, as Mn)

ACGIH TLVs, 1988-89
TLV-TWA: 5 mg/m³ (dust and compounds)
TLV-TWA: 1 mg/m³ (fume)
STEL: 3 mg/m³ (fume)

NIOSH REL, 1987
Ceiling limit: 5 mg/m³ (manganese and compounds, as Mn)
Toxicity Data*
Human, inhalation, TC_{Lo}: 2300 µg/m³

* See NIOSH, *RTECS* (OO9275000), for additional data with references to mutagenic and tumorigenic effects.

Section 3. Physical Data

Boiling Point: 3803 °F (2095 °C)*
Melting Point: 2300 °F (1260 °C)
Vapor Pressure: 1 mm Hg at 2358 °F (1292 °C)
Atomic Weight: 54.94
Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 7.20
Water Solubility: Impure Mn decomposes slowly

Appearance and Odor: Reddish-grey or silvery powder or metal. No odor.

* Other sources (Genium refs. 7, 89, and 126) give 3807 °F (2097 °C), 3564 °F (1962 °C), and 3452 °F (1900 °C) boiling points, respectively.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: *	LEL: *	UEL: None reported

Extinguishing Media: Use dry chemical extinguishing agent designed for metal fires.
Unusual Fire or Explosion Hazards: Manganese dust or powder is flammable and moderately explosive when exposed to flame or heated in carbon dioxide. Mixtures of manganese dust and aluminum dust may explode in air. Ammonium nitrate and manganese may explode when heated. Flammable hydrogen gas is generated under certain conditions (Sec. 5).
Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

* Manganese metal/powder can present a dust explosion hazard under favoring conditions of particle size and airborne dust dispersion. The minimum explosive concentration of Mn is 0.125 oz/ft³, with a minimum ignition temperature of 842 °F (450 °C). Oxygen concentrations of less than 15% prevent ignition.

Section 5. Reactivity Data

Stability/Polymerization: Manganese is stable at room temperature in closed containers. Hazardous polymerization cannot occur.
Chemical Incompatibilities: The powdered metal ignites on contact with hydrogen peroxide, bromine pentafluoride, fluorine, chlorine and heat, and sulfur dioxide and heat. It reacts violently with oxidants and nitrogen dioxide (NO_2), and incandescently with nitric acid, phosphorus, and nitryl fluoride. Manganese reacts slowly with water at 21°F (100 °C), forming hydrogen gas (flammable). Contact with acids (including dilute acids) readily dissolves Mn, with the evolution of hydrogen. Hot, concentrated potassium and sodium hydroxides also dissolve Mn, forming hydrogen and manganese hydroxide.
Hazardous Products of Decomposition: Thermal oxidative decomposition of manganese can produce manganese oxides.

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists manganese as a carcinogen.

Summary of Risks: Although an essential element for man, manganese is also toxic to humans in several ways. Acute or chronic manganese poisoning can result from excessive inhalation or ingestion. The immune system reacts to acute exposures with "metal fume fever," characterized by: fever, chills, nausea, weakness, body aches, frontal headache, occasional blurred vision, low back pain, muscle cramping, shallow respiration, throat dryness and irritation, a dry cough, a sweet or metallic taste, and chest tightness occurring over several hours. Progressive and permanent injury can result from chronic, untreated Mn poisoning. Its most notable effects are the neurological disorders caused by its ability to inhibit the chemical transmission of electrical impulses in the central nervous system. The lungs may become inflammed (manganese pneumonititis), as reported in workers exposed to manganese ores and compounds. Sufficient evidence proves that in several species, manganese is embryolethal at toxic doses. Impotence is a common symptom in grossly contaminated men.

Medical Conditions Aggravated by Long-Term Exposure: Degenerative brain changes, muscle weakness, change in motor activity.

Target Organs: Central nervous system (CNS), respiratory system, kidneys, blood.

Primary Entry: Inhalation, ingestion.

Acute Effects: High-concentration exposures may cause metal fume fever, with its onset occurring over several hours. Inhalation of large concentrations may cause managanese pneumonitis. This material is a skin and eye irritant leading to dermatitis, conjunctivitis, and corneal damage.

Chronic Effects: Exposure to manganese fume over 6 months to 2 years may harm the central nervous system, with symptoms progressing from headache, restless sleep or sleepiness, personality changes, irritability and inappropriate laughing or crying to visual hallucinations, double vision, uncontrolled impulse behavior, euphoria, and to abnormal reaction to painful stimuli, excess salivation, trembling in the extremities and head, impaired walking, and other signs similar to Parkinson's disease.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: After rinsing affected area with flooding amounts of water, wash it with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that conscious person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.

After first aid, get appropriate in-plant, paramedic, or community medical attention and support.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Remove heat and ignition sources. Ventilate spill area. Cleanup personnel should wear appropriate respiratory protective equipment. Carefully scoop spilled material, avoiding dust generation, into a suitable salvage container.

Disposal: Return scrap material to supplier or processor for recovery. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed

CERCLA Hazardous Substance (40 CFR 302.4): Not listed

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Wear a NIOSH-approved respirator where airborne concentrations exceed the ceiling limit. Fume or high-efficiency particulate filter respirators are acceptable for concentrations up to 50 mg/m^3 (250 mg/m^3 with full facepiece). Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.

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

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below OSHA, ACGIH, and NIOSH standards. Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 103). Consider the dust explosion potential of finely divided Mn powder when designing exhaust ventilation systems and other process equipment to contain heavily dust-laden air.

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Launder contaminated clothing before wearing. Remove this material from your shoes and equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry, well-ventilated area away from ignition sources, acids, alkali, and other incompatible materials. Protect containers from physical damage.

Engineering Controls: Use with adequate ventilation. Avoid breathing dust and fumes. Maintain good housekeeping practices to prevent dust accumulation. Use cleanup procedures that minimize dust generation. Practice good personal hygiene. Examine exposed personnel at regular intervals with emphasis on the respiratory and central nervous systems.

Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection **References:** 2, 4, 7, 8, 9, 12, 14, 20, 25, 27, 38, 44, 47, 55, 58, 81, 89, 90, 100, 124, 126

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** Warren Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 162
Copper

Issued: 12/85 Revision: A, 8/90

Section 1. Material Identification

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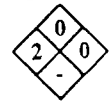
Copper (Cu) Description: Widely distributed in nature in elemental state, arsenites, sulfides, chlorides, and carbonates. Prepared by crushing, grinding, and concentrating copper ores by flotation and leaching or by smelting copper ore concentrates to yield a blister (96 to 98%) copper which is electrolytically refined to yield 99.9+% copper. Copper is the most widely used structural metal, next to iron and aluminum. Used in electric wiring; switches, heating, plumbing, roofing, and building construction; alloys (brass, bronze, Monel metal, beryllium-copper); coins; chemical and pharmaceutical machinery; electroplated protective coatings and undercoats for nickel, chromium, zinc, etc., cooking utensils; insecticides; antifouling paints; and as a catalyst. Copper whiskers are used in thermal and electrical composites. Copper flakes are used as insulation for liquid fuels.

R 0
I 4
S 1
K 0

Genium



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H 2
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Other Designations: CAS No. 7440-50-8, bronze powder, copper slag-airborne, copper slag-milled.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(TM) for a suppliers list.

Cautions: *Copper may be toxic through contact, inhalation, and ingestion.* It may cause skin and eye irritation and metal fume fever. *Copper is not considered a fire hazard, but fine particles may burn in air.*

Section 2. Ingredients and Occupational Exposure Limits

Copper, ca 100%

1989 OSHA PELs	1989-90 ACGIH TLVs	1988 NIOSH REL	1985-86 Toxicity Data‡
8-hr TWA: 1 mg/m³*	TLV-TWA: 1 mg/m³*	None established	Human, oral, TD_{Lo}: 120 µg/kg affects the gastrointestinal tract (nausea or vomiting)
8-hr TWA: 0.1 mg/m³†	TLV-TWA: 0.2 mg/m³†		Rat, oral, TD_{Lo}: 1210 µg/kg (35 weeks prior to mating) affects fertility (pre- and post-implantation mortality)

* Copper dusts and mists, as Cu.
† Copper fume.
‡ See NIOSH, *RTECS* (GL5325000), for additional reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 4703 °F (2595 °C)
Melting Point: 1981 °F (1083 °C)
Vapor Pressure: *1 mm Hg at 2962 °F (1628 °C)*
Molecular Weight: 63.546
Density/Specific Gravity: 8.94
Water Solubility: Insoluble

Appearance and Odor: Solid, various shapes, odorless, red/brown-colored metal or powder. Copper is ductile, tough, and easily worked. It is very resistant to corrosion, but readily attacked by alkalies.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: Use extinguishing media appropriate to the surrounding fire since copper does not burn. Finely divided copper burns in air, and in extreme cases ignites spontaneously.
Unusual Fire or Explosion Hazards: Liquid copper explodes on contact with water. High concentrations of fine copper particles in the air may present an explosion hazard.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and a fully encapsulating suit.

Section 5. Reactivity Data

Stability/Polymerization: Copper is stable at room temperature in closed containers under normal storage and handling conditions. However, on long standing, a white, highly explosive peroxide deposit may form. Copper's vapors are uninhibited and may form polymers in vents and flame arresters.
Chemical Incompatibilities: Copper reacts violently with ammonium nitrate, bromates, iodates, chlorates, ethylene oxide, hydrazoic acid, potassium oxide, dimethyl sulfoxide + trichloroacetic acid, hydrogen peroxide, sodium peroxide, sodium azide, sulfuric acid, hydrogen sulfide + air, and lead azide. A potentially explosive reaction occurs with actylenic compounds. Copper ignites on contact with chlorine, fluorine [above 250 °F (121 °C)], chlorine trifluoride, and hydrazinium nitrate [above 158 °F (70 °C)]. It is also incompatible with 1-bromo-2-propyne; an incandescent reaction occurs with potassium dioxide.
Conditions to Avoid: Avoid prolonged exposure to air and moisture. On exposure to moist air, copper slowly converts to the carbonate.
Hazardous Products of Decomposition: Thermal oxidative decomposition of copper can produce metallic oxides (copper fumes).

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Section 6. Health Hazard Data

Carcinogenicity: The NTP, IARC, and OSHA do not list copper as a carcinogen. Experimental studies show tumorigenic and teratogenic effects in laboratory animals.
Summary of Risks: Copper is a necessary human nutrient, excessive intake levels of which the kidneys normally eliminate. In individuals with kidney disease or, rarely, Wilson's disease (abnormal retention and storage of copper in the body that damages the liver, kidneys, brain, blood, bones, and endocrine glands), copper levels may accumulate. Significant industrial exposure to copper occurs mainly through inhalation of fumes during welding, smelting, or refining operations; or through exposure to copper dusts and mists during mining, extracting, refining, or manufacturing processes. Copper particles may irritate, discolor, and damage eyes. Exposure to copper salts in many applications is potentially toxic. Copper dusts, fumes, and salts may irritate the upper respiratory tract. Long-term exposure may irritate the skin and discolor the skin or hair.
Medical Conditions Aggravated by Long-Term Exposure: Individuals with impaired pulmonary or renal function should avoid exposure.
Target Organs: Respiratory system, skin, eyes, liver, kidneys.
Primary Entry Routes: Inhalation, ingestion.
Acute Effects: Inhalation of copper fumes may give rise to metal fume fever (after an incubation period of about 5 hr), an allergic reaction with flu-like symptoms—high temperature, metallic taste, nausea, coughing, general weakness, muscle aches, and exhaustion. These symptoms usually disappear within 24 hr. Direct contact with copper causes skin and (less often) eye irritation, and itching of the linings of the nose, mouth, and respiratory tract. Exposure to copper dust may cause a greenish-black skin discoloration. Copper ingestion causes nausea, vomiting, abdominal pain, and diarrhea. Ingestion of large doses may cause stomach and intestine ulceration, jaundice, and kidney and liver damage.
Chronic Effects: Continued exposure to copper may cause mild dermatitis and degeneration of the mucous membranes. Repeated or prolonged exposure to copper dusts and mists can discolor skin and hair and irritate the skin. Repeated inhalation can cause chronic respiratory disease. Individuals with Wilson's disease (1 in 200,000 individuals) are more susceptible to chronic copper poisoning. If undetected and untreated, this progressive condition is eventually fatal.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing with artificial respiration.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: A blood count shows leucocytosis if an individual has metal fume fever. Consider chellation with penicillamine or BAL (British Anti-Lewisite or dimercaprol) for chronic intoxication.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, remove all heat and ignition sources, and provide adequate ventilation. Avoid creating dusty conditions. Cleanup personnel should protect against vapor inhalation and skin and eye contact. Cleanup methods such as vacuuming (with the appropriate filter) or wet mopping minimizes dust dispersion. Absorb liquid containing copper with vermiculite, dry sand, or other inert materials. Place in appropriate containers for disposal. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per Clean Water Act, 307(a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Some recommendations follow. For copper dust and mists greater than 50 mg/m^3, wear a high-efficiency particulate respirator, a supplied-air respirator, or an SCBA, all with a full facepiece. For copper dust and mists greater than 2000 mg/m^3, wear a supplied-air respirator equipped either with a full facepiece operated in pressure-demand or positive-pressure mode or with a hood in continuous-flow mode. For copper fumes over 100 mg/m^3, wear either a powered air-purifying respirator with a high-efficiency filter, or a supplied-air respirator equipped either with a full facepiece operated in pressure-demand or positive-pressure mode or with a hood in continuous-flow mode. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Eye and face protection is required when grinding, welding, cutting, or remelting. Protect skin from molten metal and radiant heat when melting scrap. Machine turnings may also present a laceration hazard. When handling oil-contaminated copper, wear rubber gloves to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below OSHA PELs and ACGIH TLVs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store copper in tightly closed containers in a cool, dry, well-ventilated area. Avoid exposure to air and moisture.
Engineering Controls: Avoid dust and fume inhalation and direct contact with skin and eyes. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures. Maintain exposures below the PEL/TLV. Monitor copper dust and mist levels in the air.
Other Precautions: Provide placement and periodic examinations that emphasize the skin, eyes, and respiratory system. Prevent exposing individuals with chronic respiratory disease or Wilson's disease.
Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection **References:** 26, 38, 73, 84, 88, 89, 100, 101, 103, 109, 124, 126, 127, 132, 133, 134, 136, 138, 139, 143, 144
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheet Collection

Silver **MSDS No. 181**

Date of Preparation: 4/86 Revision: A, 6/94

Section 1 - Chemical Product and Company Identification 44

Product/Chemical Name: Silver
Chemical Formula: Ag
CAS No.: 7440-22-4
Synonyms: argentum
Derivation: Occurs naturally in sea water (0.01 ppm) and the earth's crust (0.1 ppm). Silver containing ores include argentite, stephanite, polybasite, proustite, pyrargyrite, and cerargyrite. Extraction of silver is essentially as a by-product of copper, lead, or zinc extraction and this accounts for 3/4 of its production. The two main production methods are *slime melting* from electrolytic refining of copper and the *Parkes process* from lead and zinc ores.
General Use: Used in the manufacture of jewelry, tableware, ornaments, mirrors, electrical contacts, batteries, solder; in photography, dental amalgams; as a sterilant, for water purification, and as a coating for the inside of light bulbs (sandwiched between two layers of titanium oxide).
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Silver, ca 100 % wt. 97.5 % silver + 2.5 % copper = *sterling* silver.

OSHA PEL
8-hr TWA: 0.01 mg/m^3

ACGIH TLV
TWA: 0.1 mg/m^3

NIOSH REL
10-hr TWA: 0.01 mg/m^3

DFG (Germany) MAK
TWA: 0.01 mg/m^3 (total dust)
Category III: Substances with systemic effects
Onset of Effect: > 2 hr
Half-life: > shift length (strongly cumulative)

Peak Exposure Limit:
0.1 mg/m^3, 30 min. average value, 1/shift

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Silver exists as a hard, brilliant white, malleable metal. It is noncombustible as a solid, but the finely divided powder is flammable. Silver has no known function in man and appears to have low toxicity other than a localized or general bluish-gray pigmentation of the mucous membranes, eyes, and skin due to deposition of silver particles over a period of time. The condition called *argyria* appears to be more of a cosmetic problem than a toxicological concern.

Wilson Risk Scale	
R	1
I	4
S	1
K	0

HMIS	
H	1*
F	0
R	0

*Chronic effects
PPE†
†Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin and eye contact.
Target Organs: Skin, eyes (especially the conjunctiva), and mucous membranes.
Acute Effects
Inhalation: Heavy exposure of a worker to heated metallic silver vapor for 4 hr caused lung damage and pulmonary edema (fluid in lungs). Diffuse pulmonary fibrosis is also possible.
Eye and Skin: Effects are generally chronic.
Carcinogenicity: IARC, NTP, and OSHA do not list silver as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Chronic Effects: The main effect associated with exposure to silver is argyria, a bluish-gray pigmentation of the eyes, skin, and mucous membranes caused by deposition of silver particles. This effect can be either local or generalized. It appears that localized deposition occurs by penetration of fine, metallic particles and that generalized argyria occurs from inhalation or ingestion of silver salts. It is estimated that a gradual intake of 1 to 5g silver will lead to generalized argyria. Generalized argyria appears to be darker in areas exposed to the light. Silver deposition in the respiratory tract may result in a mild chronic bronchitis. Silver polishers exposed for long periods to silver and polishing dusts have developed increased lung densities (shown by x-ray). Argyria of the eyes is not accompanied by vision loss although there may be some difficulty adapting to the dark. There is some evidence for skin absorption; amalgam tattoos (accidental implantation of dental amalgams) caused fatigue, headache, sinusitis, and weight loss. Repeated skin contact may cause allergic contact dermatitis in some individuals.
Other: The reason that silver toxicity rarely occurs beyond argyria is due to rapid binding to various proteins and precipitation of silver chloride. Tissue damage only occurs when this binding ability is altered by a heavy dose. Kidney, liver, and neurologic damage has been associated with silver, but these cases are not well documented.

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Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed.
Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin Contact: *Quickly* remove contaminated clothing. Rinse away loose material and move quickly to a soap and water wash.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Silver deposited in tissues is relatively inert and does not respond well to chelation therapy. There is no known treatment for argyria. Background serum levels of silver vary widely: 0.004 mcg/g to 0.03 mcg/g of blood. Discoloration of Descemet's membrane is the most sensitive indicator of chronic exposure to silver. Background excretion is 8 to 28 nmol/L. In one study, the urinary enzyme, N-acetyl-ß-D glucosaminidase was significantly elevated and correlated with blood silver concentrations and age. It may be an indicator of exposure.

Section 5 - Fire-Fighting Measures

Flash Point: Noncombustible as the solid.
Autoignition Temperature: None reported.
LEL: None reported.
UEL: None reported.
Extinguishing Media: Use agents suitable for surrounding fire.
Unusual Fire or Explosion Hazards: None reported.
Hazardous Combustion Products: Silver fumes.
Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways.
Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.
* Flammable when in highly divided powder form.

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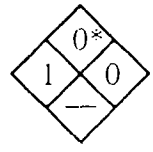

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area. Cleanup personnel should protect against inhalation and skin/eye contact with dusts.
Spills: Carefully scoop up spill and place in sealed containers for reclamation.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Wear appropriate PPE to avoid inhalation or skin/eye contact with silver dusts.
Storage Requirements: Store in a cool, dry, well-ventilated area away from incompatibles (Sec. 10).

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: No special controls needed.
Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103)
Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the skin, eyes, and mucous membranes (for presence of argyria).
Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For ≤ 0.25 mg/m^3, use any supplied-air respirator (SAR) operated in continuous-flow mode or any powered, air-purifying respirator with a high-efficiency particulate filter. Use eye protection when necessary. For ≤ 0.5 mg/m^3, use any high-efficiency particulate filter respirator with a full facepiece, any SCBA with a full facepiece, or any SAR with a full facepiece. For ≤ 20 mg/m^3, use any SCBA or SAR (with auxiliary SCBA) with a full facepiece and operated in pressure demand or other positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Protective Clothing/Equipment: Wear protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.
Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove silver from your shoes and clean personal protective equipment. *Do not* shake dust off contaminated clothing; vacuum with a HEPA filter.

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Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using silver, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Solid
Appearance and Odor: Hard, brilliant white, lustrous, ductile, malleable metal; odorless.
Vapor Pressure: 0 mm Hg at 77 °F (25 °C), 100 mm Hg at 3389 °F (1865 °C)
Atomic Weight: 107.868
Density: 10.5 g/mL
Thermal Conductivity: 101 cal/cm/sec/ °C

Water Solubility: Insoluble
Other Solubilities: Insoluble in most cold acids except dilute nitric acid. Reacts with hot, concentrated sulfuric acid. Soluble in fused alkali hydroxides in the presence of air, fused alkali peroxides, and in alkali cyanides in presence of air or oxygen.
Boiling Point: 4013 °F (2212 °C)
Melting Point: 1763 °F (961 °C)

Section 10 - Stability and Reactivity

Stability: Silver is stable at room temperature in closed containers under normal storage and handling conditions.
Polymerization: Hazardous polymerization does not occur.
Chemical Incompatibilities: Include acetylene and acetylenic compounds (forms explosive silver acetylides), aziridine, bromine azide, 3-bromopropyne, carboxylic acids, copper + ethylene glycol, electrolytes + zinc, ethanol + nitric acid, ethylene oxide, ethyl hydroperoxide, iodoform, ethyleneimine, peroxomonosulfuric acid, and peroxyformic acid. Silver is flammable by chemical reaction with ammonia, chlorine trifluoride, ethylene imine, hydrogen peroxide, oxalic acid, and tartaric acid. It turns black (tarnishes) on contact with ozone, sulfur, or hydrogen sulfide.
Conditions to Avoid: Contact with incompatibles.
Hazardous Decomposition Products: Silver fumes will be given off when heated.

Section 11- Toxicological Information

Toxicity Data:*

Carcinogenicity: Rat, multiple routes: 330 mg/kg/43 weeks (intermittently) caused tumors at site of application.

* See NIOSH, *RTECS* (VW3500000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Sticklebacks, LD_{50} = 0.004 mg/L/168 hr; sticklebacks, LD_{50} = 0.1 mg/L/24 hr. Although silver accumulates in body tissue it does not appear to bioaccumulate through the food chain (no magnification at higher trophic levels).
Environmental Degradation: In water, silver will undergo absorption by manganese dioxide and precipitation with halides.

Section 13 - Disposal Considerations

Disposal: Return silver and silver-containing solutions from photography and x-rays to supplier for reclamation. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101): Not listed

Shipping Name:
Environmentally hazardous substances, solid, n.o.s.*
Shipping Symbols: —
Hazard Class: 9
ID No.: UN3077
Packing Group: III
Label: Class 9
Special Provisions (172.102): 8, B54, N50

Packaging Authorizations
a) Exceptions: 173.155
b) Non-bulk Packaging: 173.213
c) Bulk Packaging: 173.240

Quantity Limitations
a) Passenger, Aircraft, or Railcar: None
b) Cargo Aircraft Only: None

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: —

* Classified as a hazardous substance when silver is in a quantity, in one package, which equals or exceeds the RQ of 1000 lb (454 kg)

Section 15 - Regulatory Information

EPA Regulations:
RCRA Hazardous Waste Classification (40 CFR 261.24): D011, Characteristic of Toxicity (regulatory level = 5 mg/L)
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per CWA, Sec. 307(a)
CERCLA Reportable Quantity (RQ), 1000 lb (454 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed

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OSHA Regulations:
Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A): Not listed

Section 16 - Other Information

References: 73, 103, 124, 132, 136, 148, 149, 167, 176, 187, 189
Prepared By ..... M Gannon, BA
Industrial Hygiene Review ..... RE Langford, PhD, CIH
Medical Review ..... T Thoburn, MD, MPH
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Material Safety Data Sheet Collection

Chromium (III) Oxide MSDS No. 182

Date of Preparation: 4/86 Revision: A, 6/94

Section 1 - Chemical Product and Company Identification 44

Product/Chemical Name: Chromium (III) Oxide
Chemical Formula: Cr_2O_3
CAS No.: 1308-38-9
Synonyms: chrome green, chrome oxide, chromic oxide, chromium sesquioxide, chromium (3^+) trioxide, dichromium trioxide, green cinnabar, oxide of chromium
Derivation: Prepared by reaction of sodium dichromate or chromate with sulfur or by heating chromic hydroxide or dry ammonium dichromate.
General Use: Used in abrasives, electrical semiconductors, alloys; for printing fabrics and bank notes; as a component of refractory bricks and green asphalt roofing, sensitizer in photochemical processing, a colorant for latex paints, cement, paper, and rubber, and as a catalyst in preparation of methanol, butadiene, and high density polyethylene.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Chromium (III) Oxide, > 95.5 % wt.
Trace Impurities: moisture 0.3%, iron 0.05%, sulfur 0.2%, inert material 0.75%, other water soluble material 0.2%.

OSHA PEL
Chromium (III) compounds, as Cr
8-hr TWA: 0.5 mg/m^3

NIOSH REL
Chromium (II) & (III) compounds, as Cr
10-hr TWA: 0.5 mg/m^3

DFG (Germany) MAK
None established

ACGIH TLV
Chromium (III) compounds, as Cr
8-hr TWA: 0.5 mg/m^3

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Chromium (III) oxide exists as small green crystals or powder. It has very low toxicity due to poor membrane (skin and mucous membrane) permeability. Chromium (III) oxide is not combustible itself, but as an oxidizer it is capable of igniting combustible materials and increasing the intensity of a fire.

Wilson Risk Scale	
R	1
I	3
S	1
K	0

HMIS	
H	1
F	0
R	0
PPE*	

*Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin and eye contact.
Target Organs: Skin, eyes, respiratory tract.
Acute Effects
Inhalation: May cause minor irritation of the respiratory tract.
Eye: May cause minor irritation.
Skin: May cause minor irritation.
Ingestion: When taken orally, trivalent chromium compounds do not produce any local or systemic effects because of poor absorption.
Carcinogenicity: NTP and OSHA do not list chromium (III) oxide as a carcinogen. IARC has evaluated chromium (III) oxide and designated it as Class 3, unclassifiable as to human carcinogenicity. In general, hexavalent (VI) chromium compounds have been found to be carcinogenic, but trivalent (III) compounds have not.
Medical Conditions Aggravated by Long-Term Exposure: Possibly, dermatitis.
Chronic Effects: Dermatitis is possible in sensitive individuals. In a case study of 85 chrome factory workers exposed to 4.5 to 9.2 mg/m^3 of chromium (III) compounds, 18.8% developed chronic bronchitis after 5 yr and 5.9% developed pneumoconiosis after 9 yr.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed.
Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water for at least 15 minutes. If pain or irritation persists, consult an ophthalmologist.
Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water followed by a soap and water wash.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water to dilute.
After first aid, get appropriate in-plant, paramedic, or community medical support.

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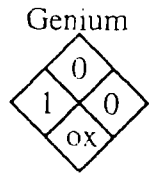
Note to Physicians: Urinary excretion is generally < 10 µg/day in absence of excess exposure. Treat weeping dermatitis with 1% aluminum acetate wet dressings.

Section 5 - Fire-Fighting Measures



Flash Point: Noncombustible
Autoignition Temperature: Noncombustible
LEL: None reported.
UEL: None reported.
Extinguishing Media: Use agents suitable for surrounding fire.
Unusual Fire or Explosion Hazards: Although chromium (III) oxide is noncombustible, it is an oxidizer capable of igniting combustible materials and increasing the intensity of a fire.
Hazardous Combustion Products: None
Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways.
Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel should protect against inhalation and skin/eye contact. Immediate clean-up is necessary to prevent dust dispersion.
Small Spills: Damp mop or vacuum (with appropriate filter). *Do not* sweep!
Large Spills
Containment: Flush spills with water to containment area for reclamation or disposal. *Do not* release into sewers or waterways.
Cleanup: Damp mop any residue.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Prevent dust dispersion.
Storage Requirements: Store in a cool, dry, well-ventilated area away from incompatibles (Sec. 10). *Do not* store on wooden floors or shelves (oxidizer - capable of igniting combustible materials).

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Enclose all processes where possible to prevent dust dispersion into work area.
Ventilation: Provide general or local exhaust ventilation systems to maintain airborne levels below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Administrative Controls: Consider preplacement and periodic (annual) medical exams of exposed workers with emphasis on the respiratory system (including a 14" x 17" chest roentgenogram and FVC/FEV).
Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For ≤ 2.5 mg/m^3, use any dust and mist respirator. For ≤ 5 mg/m^3, use any dust and mist respirator except single-use and quarter mask respirators; any supplied-air respirator (SAR); or any SCBA. For ≤ 12.5 mg/m^3, use any powered, air-purifying respirator with a dust and mist filter or any SAR operated in continuous-flow mode. For ≤ 25 mg/m^3, use any air-purifying, full facepiece respirator with a high-efficiency particulate filter; any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter; or any SAR or SCBA with a full facepiece. For ≤ 250 mg/m^3, use any SAR with a full facepiece and operated in pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.
Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove chromium (III) oxide from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using chromium (III) oxide, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

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Section 9 - Physical and Chemical Properties

Physical State: Solid
Appearance and Odor: Light to dark green, fine, hexagonal crystals or powder which turn brown upon heating. The crystals will scratch quartz, topaz, or zircon.
Formula Weight: 152.02
Specific Gravity (H_2O=1, at 4 °C): 5.21
Water Solubility: Nearly insoluble
Other Solubilities: Practically insoluble in alcohol and acetone. Slightly soluble in acids and alkalis.
Boiling Point: 7232 °F (4000 °C)
Melting Point: 4415 °F (2435 °C)
Refractive Index: 2.551

Section 10 - Stability and Reactivity

Stability: Chromium (III) oxide is stable at room temperature in closed containers under normal storage and handling conditions.
Polymerization: Hazardous polymerization does not occur.
Chemical Incompatibilities: Chromium (III) oxide is reduced to the 2+ oxidation state by hypophosphites, electrolysis, or reducing metals such as zinc, magnesium, and aluminum in acid solution. It is incompatible with lithium + heat 1769 °F (965 °C), oxygen difluoride, glycerol (explodes), chlorine trifluoride, and rubidium acetylide.
Conditions to Avoid: Exposure to incompatibles and dispersion of dusts into air.
Hazardous Decomposition Products: None reported.

Section 11- Toxicological Information

Toxicity Data:*

Carcinogenicity:
Rat, intraperitoneal: 90 mg/kg caused respiratory and kidney tumors.
Mutagenicity:
Hamster, lung cell: 34 mg/L caused sister chromatid exchange.

* See NIOSH, *RTECS* (GB6475000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: There is little tendency for bioaccumulation along the food chain. The BCF (chromium III compounds) for saltwater organisms = 86 to 153.
Environmental Degradation: In water, chromium (III) oxide is expected to eventually precipitate to sediments. The estimated residence time of *chromium* in lake water is 4.6 to 18 yr. In air, chromium (III) oxide is primarily removed by fallout and precipitation. Soils with a high chromium (all compounds included) content (> 0.2%) are expected to be infertile. The half-life of chromium in soils may be several years.

Section 13 - Disposal Considerations

Disposal: Chromium (III) oxide is a poor candidate for incineration. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101): Not listed

Section 15 - Regulatory Information

EPA Regulations:
RCRA Hazardous Waste Classification (40 CFR 261.21): D001, Characteristic of Ignitability (oxidizer).
Listed as (chromium compounds) a CERCLA Hazardous Substance (40 CFR 302.4) CWA, Sec. 311 (b)(4)
CERCLA *Statutory* Reportable Quantity (RQ), 1 lb (0.454 kg)
Listed as (chromium compounds) a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 73, 103, 124, 132, 136, 148, 149, 167, 176, 187, 189, 192

Prepared By.....M Gannon, BA
Industrial Hygiene Review.....DJ Wilson, CIH
Medical Review.....T Thoburn, MD, MPH

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GENIUM PUBLISHING CORP.

No. 216

MAGNESIUM METAL
(Ribbons/Turnings)

Issued: August 1987

SECTION 1. MATERIAL IDENTIFICATION 23

MATERIAL NAME: MAGNESIUM METAL (RIBBONS/TURNINGS)

DESCRIPTION (Origin/Uses): Prepared by electrolysis of a mixture of magnesia and mercuric oxide. Used in alloys of light metals, in pyrotechnics, flashbulbs and flares; as a Grignard reagent; for recovery of titanium.

OTHER DESIGNATIONS: Mg; NIOSH *RTECS* #OM2100000; CAS #7439-95-4

TRADE NAMES/VENDORS: MAGNESIUM METAL, Reade Manufacturing Co.

MANUFACTURER/SUPPLIER: Available from several suppliers, including: Reade Manufacturing Co., Ridgeway Blvd., Lakehurst, NJ 08733; Telephone: (201) 657-6451

COMMENTS: Combustible magnesium metal in the form of fine powder, thin sheets, and turnings is easily ignited and burns with intense heat. Powders form explosive mixtures in air that can be ignited by a spark.

HMIS	
H	1
F	3
R	3
PPE*	

* See sect. 8

R	1
I	1
S	1
K	4

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Magnesium Metal, CAS #7439-95-4, NIOSH *RTECS* #OM2100000 Magnesium Oxide (Fumes), CAS #1309-48-4; NIOSH *RTECS* #OM3850000 * Current 1987-88 ACGIH TLV Comments: Primarily hazardous as a combustible metal.	100	Hazard and Toxicity Data TLV:10 mg/m^3 as Magnesium Oxide* TLV: Magnesium Metal: None Established Toxic Dose for Magnesium Oxide Human, Inhalation, TC_{Lo}: 400 mg/m^3 (Toxic Effects: Unspecified in Source) Hamster, Intratracheal, TD_{Lo}: 480 mg/kg (30 Weeks, Intermittent Toxic Effects: Equivocal Tumorigenic Agent)

SECTION 3. PHYSICAL DATA

Boiling Point ... 2025°F (1107°C)
Vapor Pressure ... 1 Torr at 1150°F (621°C)
Water Solubility ... Insoluble
Vapor Density ... Negligible
Evaporation Rate ... Negligible

Specific Gravity ... 1.740
Melting Point ... 1300°F (649°C)
Percent Volatile by Volume ... Not Found
Molecular Weight ... 24.31 Grams/Mole
pH ... Water Solution Alkaline (pH >7)

Appearance and odor: Silvery white metal. Odorless.

Comments: Solvent solubility: mineral acids, concentrated hydrofluoric acid ammonium salts.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
Combustible	Not Found	Not Found	Not Found	Not Found

EXTINGUISHING MEDIA: Use G-1® graphite powder, Met-L-X® powder, powdered talc, dry graphite, powdered sodium chloride, soda ash, or other suitable powders. WARNING: Do not use foam, carbon tetrachloride, carbon dioxide, or water to extinguish magnesium fires, because dangerous reactions will occur (see sect. 5). UNUSUAL FIRE/EXPLOSION HAZARDS: Magnesium may react with moisture or acids to evolve hydrogen gas (H_2), which is a highly dangerous fire or explosion hazard. It will react violently with oxidizing materials. SPECIAL FIRE-FIGHTING PROCEDURES: During machining, magnesium fires may result from use of dull cutting tools or making light (thin) cuts at high speed. Magnesium turnings and borings should be collected frequently during working hours. Store them in clean, dry, metal-covered containers labeled "Magnesium Only." Fire fighters should protect their eyes and skin from flying particles. In order to prevent eye injury, do not look directly at magnesium fires. Wear protective breathing apparatus. In the case of massive magnesium fires, protect nearby facilities and let the fire burn.

SECTION 5. REACTIVITY DATA

Magnesium is stable. Hazardous polymerization cannot occur.

CHEMICAL INCOMPATIBILITIES: This material will react violently with chlorinated solvents, methanol, hydrogen peroxide, oxidizing agents, sulfur compounds, animal and vegetable oils, water, metal oxides, metal cyanides, metal oxide salts, oxygen, and tellurium compounds. CONDITIONS TO AVOID: Magnesium may ignite itself if it is exposed to air or in the presence of moisture. It may reignite itself after the fire is extinguished. Its violent reaction with water will generate hydrogen. Prohibit open flames or electrical or gas cutting or welding equipment where magnesium dust is produced or handled. Special precautions are needed to prevent ignition while dressing grinding wheels. Use nonsparking tools in dusty situations. PRODUCTS OF HAZARDOUS DECOMPOSITION: Magnesium oxide. COMMENTS: Fire fighters should not breathe fumes from magnesium fires. Smoking must be prohibited in all areas where magnesium is found.

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SECTION 6. HEALTH HAZARD INFORMATION

Magnesium is not listed as a carcinogen by the NTP, IARC, or OSHA.
SUMMARY OF RISKS: Magnesium metal does not have well-characterized toxicity. Magnesium particles imbedded in the skin can produce sores that resist healing and an accumulation of gas under the skin and gaseous blebs (small blisters). Inhalation of magnesium fumes may cause metal fume fever. Magnesium oxide (MgO) fumes can irritate the nose and throat. Magnesium oxide has a TLV of 10 mg/m^3, while the TLV for magnesium metal is unavailable. TARGET ORGANS: Upper respiratory tract and lungs, skin, eyes, and central nervous system. PRIMARY ENTRY: Inhalation or oral ingestion of magnesium salts. ACUTE EFFECTS: Magnesium fumes in oxide form can irritate the eyes, nose and throat and cause metal fume fever with febrile conditions, cough, a feeling of pressure on the chest, and leukocytosis (an increase in the number of leukocytes circulating in the blood). Spills of molten magnesium can cause skin burns. CHRONIC EFFECTS: None reported. MEDICAL CONDITIONS AGGRAVATED BY LONG-TERM EXPOSURE: Intoxication may be caused by oral administration of magnesium salts to someone with kidney disease.
FIRST AID: EYE CONTACT: Immediately flush eyes, including under the eyelids, gently but thoroughly for at least 15 minutes. Get medical help.* SKIN CONTACT: Wash thoroughly after handling magnesium. Get medical help.* INHALATION: Remove victim to fresh air; restore and/or support his breathing as needed. Avoid prolonged or repeated exposure to magnesium. If victim is not breathing, give him artificial respiration. Get medical help.* INGESTION: Rinse victim's mouth with water; give him 2 or 3 glasses of water to drink. Do not induce vomiting. Never give anything by mouth to someone who is unconscious or convulsing. Magnesium metal has a low oral toxicity. Get medical help.*
* GET MEDICAL ASSISTANCE = IN PLANT, PARAMEDIC, COMMUNITY. Seek prompt medical assistance for further treatment, observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK: Remove any sources of ignition from a magnesium spill. Do not use water in cleanup or get spilled material wet. Use nonsparking tools. Place waste in clean, dry, metal containers and remove them to clean, dry storage.
WASTE DISPOSAL: Magnesium scrap is usually reclaimed for economic value. Small amounts may be disposed of in landfills. Follow Federal, state, and local regulations.
EPA Hazardous Waste Number (40 CFR 261.21, Ignitability): D001
Both magnesium metal and magnesium oxide are reported in the 1980 EPA TSCA Inventory.
Aquatic Toxicity Rating: TLm96: Over 1000 ppm for magnesium oxide.
Magnesium is not designated as a hazardous substance by the EPA (40 CFR 116.4).
EPA Reportable Quantity (40 CFR 117.3): Not Listed

SECTION 8. SPECIAL PROTECTION INFORMATION

GOGGLES: Wear dust-resistant goggles or face shields to prevent eye contact with magnesium. GLOVES: Wear impervious gloves to prevent prolonged contact with skin. RESPIRATOR: Where high dust levels prevail, use a NIOSH-approved dust mask. VENTILATION: Where dusty conditions prevail, provide dry, explosion-proof ventilation. Eliminate all possible sources of ignition/explosion.
SAFETY STATIONS: Eyewash stations, washing facilities, and safety showers should be available in areas of use and handling.
CONTAMINATED EQUIPMENT: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Particles may cling to contact lens surfaces and cause corneal injury.
COMMENTS: Practice good personal hygiene. Keep material off your clothes and equipment. Avoid transferring material from hands to mouth while eating, drinking, or smoking.
In all cases prevent contact with fire sources or possible chemical mixing, because this metal is highly reactive (see sect. 5).

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

STORAGE SEGREGATION: Store magnesium in tightly closed containers in a cool, dry, well-ventilated area away from fire sources or combustibles. Protect containers from physical damage. SPECIAL HANDLING/STORAGE: Use nonsparking tools when working with or near this material. Store massive amounts of magnesium bars in the open, as is done with aluminum or steel. ENGINEERING CONTROLS: Install ventilation systems that maintain airborne levels of magnesium oxide below 10 mg/m^3. Ground and bond all metal containers. Eliminate all possible sources of ignition.
OTHER PRECAUTIONS: Avoid inhaling dust or letting it come in contact with your eyes. Practice good personal hygiene when handling this material. Prohibit all use of tobacco near magnesium. COMMENTS: Do not take this material out of your work area or to your home on your clothing or equipment.
TRANSPORTATION DATA (per 49 CFR 172.101-2):
DOT Shipping Name: Magnesium Metal DOT Hazard Classification: Flammable Solid DOT ID No. UN1869
DOT Required Label: Flammable Solid; Dangerous When Wet Additional DOT Requirements: Segregation, the same as for flammable solids labeled Dangerous When Wet.
References: 1-12, 18, 24, 37, 39, 44, 82, 84, 87-102. OW

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Indust. Hygiene/Safety 11-18-87
Medical Review 11-20-87

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GENIUM PUBLISHING CORP.

No. 217

POTASSIUM METAL

Issued: August 1987

SECTION 1. MATERIAL IDENTIFICATION

23

MATERIAL NAME: POTASSIUM METAL

DESCRIPTION (Origin/Uses): Natural substance. Prepared by electrolysis of fused potassium hydroxide. Used as a reagent and reducing agent in many chemical reactions; in the metallic state emits weak beta radiation; potassium 40 is a naturally occurring radioactive isotope.

OTHER DESIGNATIONS: K; *Kalium*; CAS #7440-09-7

HMIS

H: 3	R 3
F: 2	I -
R: 2	S 4
PPG*	K 4

* See sect. 8

MANUFACTURER/SUPPLIER: This material is available from several suppliers, including: Sharpe Chemical Co., 1116 S. Varney Street, Burbank, CA 91502; Telephone: (818) 841-7605

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Elemental Potassium, Technical Grade, CAS #7440-09-7	ca 100	Elemental Potassium: No Exposure Limits Established
*Current 1987-88 ACGIH TLV		Potassium plus Water Yields Potassium Hydroxide (CAS # 1310-58-3): TLV* 2 mg/m^3 (as Ceiling)
COMMENTS: Harmful if swallowed, inhaled, or absorbed through the skin. Causes burns. Reacts with moisture to form potassium hydroxide, which is extremely destructive to mucous membranes, upper respiratory tract, eyes, and skin.		

SECTION 3. PHYSICAL DATA

Boiling Point ... 1418°F (770°C)
Vapor Pressure .. Not Found
Water Solubility ... Reacts Violently in Water
Vapor Density ... Not Found
Evaporation Rate ... Not Found

Specific Gravity (H_2O = 1) ... 0.862 at 68°F (20°C)
Melting Point ... 146.6°F (63.7°C)
% Volatile by Volume ... Not Found
Molecular Weight ... 39.10 Grams/Mole
pH ... Water Solution Alkaline (pH >7)

Appearance and odor: Malleable (soft), silvery metal, rapidly oxidized (to gray) in moist air. Odorless.

COMMENTS: Solvent Solubility: soluble in liquid ammonia, aniline, mercury, and ethylenediamine.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
Flammable Solid	Not Found	Not Found	Not Found	Not Found

EXTINGUISHING MEDIA: Do not use water, foam, carbon dioxide, or halogenated extinguishing agents (such as Halon® or carbon tetrachloride). Use dry graphite (G-1® graphite powder), soda ash, powdered sodium chloride, or suitable dry powder (Met-L-X®). UNUSUAL FIRE/EXPLOSION HAZARDS: Potassium metal is extremely dangerous in contact with moisture or water, releasing hydrogen with sufficient heat to cause ignition or explosion. It ignites spontaneously in air or oxygen. It burns violently accompanied by explosions, which can cause spattering of material. It reacts with water and halogenated hydrocarbons. It may form reactive peroxides at room temperature even when stored under oil. Peroxides may be explosive. SPECIAL FIRE-FIGHTING PROCEDURES: Fire fighters should move containers from the fire area, if possible (see *DOT Emergency Response Guidebook*, p. 5800.3). Burning potassium is difficult to extinguish. COMMENTS: This material is dangerous when exposed to air in a heated environment (fire); it will emit toxic potassium oxide fumes; it will react with water to produce heat, hydrogen gas, and flammable vapors. Fire fighters should use full protective equipment, including self-contained breathing apparatus (SCBA) with full facepiece operated in pressure-demand or positive-pressure mode. Fire fighters should wear heavy, chemical-resistant rubber gloves.

SECTION 5. REACTIVITY DATA

Potassium metal is not stable and may readily undergo violent chemical change. It will react violently or explosively with water and may react spontaneously with air. Hazardous polymerization cannot occur. CHEMICAL INCOMPATIBILITIES: Mixing potassium metal with air, moist air, compounds of heavy metals such as silver oxide and silver chloride, halogenated hydrocarbon (chlorinated solvents), water, alkalies, carbon dioxide, petroleum ether, benzene, carbon monoxide and water, halogens, and acids causes hazardous reactions. It is incompatible with Teflon®. CONDITIONS TO AVOID: This material may ignite spontaneously if exposed to air or if it is in the presence of moisture. It is dangerous when exposed to moisture; keep it dry at all times. PRODUCTS OF HAZARDOUS DECOMPOSITION: Toxic fumes from hazardous decomposition of potassium include potassium oxide, which can react with moisture or steam to produce heat, potassium hydroxide (corrosive), and flammable hydrogen gas. CAUTION: Potassium metal will form explosive peroxides (K_2O_2) and the superoxide (KO_3 or K_2O_4) at room temperature even when stored under oil. Oxidized metal in storage under oil may explode violently when handled or cut; handle potassium metal with extreme care, minimizing any shocks.

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SECTION 6. HEALTH HAZARD INFORMATION

Potassium metal is not listed as a carcinogen by the NTP, IARC, or OSHA.
SUMMARY OF RISKS: Potassium metal is harmful if inhaled, swallowed, or absorbed through the skin and mucous membranes. It is corrosive to skin, eyes, body tissue, and the upper respiratory tract. It may react violently and explosively on contact with wet skin tissue, causing chemical and thermal burns. TARGET ORGANS: Eyes, skin, mucous membranes, respiratory tract. PRIMARY ENTRY: Skin and eye contact. SECONDARY ENTRY: Inhalation. ACUTE EFFECTS: Corrosive to all body tissue. May cause burns, ulceration, or tissue death, severe eye damage (corneal burns or opacification), and possible blindness. Inhalation of dust or fumes (especially from a fire involving potassium) will cause shortness of breath, nausea, headache, and nose and respiratory tract irritation (pneumonitis). If swallowed, potassium will cause severe pain, vomiting, diarrhea, and possible collapse. CHRONIC EFFECTS: Possible chronic dermatitis, mucous membrane irritation, and lung damage. MEDICAL CONDITIONS AGGRAVATED BY LONG-TERM EXPOSURE: None reported.
FIRST AID: EYE CONTACT: Immediately flush eyes, including under the eyelids, gently but thoroughly for at least 15 minutes. Get medical help.* SKIN CONTACT: Remove potassium-contaminated clothing immediately. Wash affected area with mild soap and water until all traces of the chemical are removed. In case of chemical burn, treat as indicated. Get medical help immediately.* INHALATION: Remove victim to fresh air. If he is not breathing, give him artificial respiration, preferably mouth-to-mouth resuscitation. If his breathing is difficult, give him oxygen. Get medical help promptly.* INGESTION: If potassium has been swallowed, and victim is conscious, use gastric lavage followed by a dose of olive oil or demulcent. Never give anything by mouth to someone who is unconscious. Get medical help immediately.*
* GET MEDICAL ASSISTANCE = IN PLANT, PARAMEDIC, COMMUNITY. Seek prompt medical assistance for further treatment, observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK: Do not touch spilled potassium metal. Shut off all sources of ignition. Do not spill water on the material or inside its container. For small dry spills shovel the waste into a clean, dry container and cover it. For small liquid spills take up the waste with sand or absorbent material and contain it as described above. Wear self-contained breathing apparatus and heavy, chemical-resistant gloves and protective clothing. WASTE DISPOSAL: Do not dilute the waste with liquid or put it down any open drain or sewer. Follow Federal, state, and local regulations.
EPA Hazardous Waste No. (40 CFR 261.21, Ignitability): D001
CERCLA Ratings (Scale 0-3): Health, 3; Fire, 1; Reactivity, 2; Persistence, 2
EPA Reportable Quantity (40 CFR 117.3): Not Listed
Potassium is not designated as a hazardous substance by EPA (40 CFR 116.4).

SECTION 8. SPECIAL PROTECTION INFORMATION

GOGGLES: Wear chemical splash-proof and dust-resistant goggles and/or face shield (8-inch minimum) with approved safety glasses to prevent eye and face contact. There is always the potential for the violent splattering of potassium metal.
GLOVES: Wear appropriate heavy, chemical-resistant gloves. RESPIRATOR: Where high levels of potassium metal dusts, fumes, or potassium hydroxide may exist, wear self-contained breathing apparatus as described under special fire-fighting procedures (see sect. 4). OTHER: Wear chemical-resistant apron or clothing. WORKPLACE CONSIDERATIONS/ VENTILATION: Use this material only under a chemical fume hood, under localized ventilation, or where general dilution ventilation is adequate. SAFETY STATIONS: Eyewash stations, washing facilities, and safety showers should be available in areas of use and handling because potassium is corrosive to eyes and body tissue.
CONTAMINATED EQUIPMENT: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Particles may cling to contact lens surfaces and cause corneal injury.
SPECIAL CONSIDERATIONS: Avoid all contact with material. Keep material off of your clothing and equipment.
COMMENTS: Practice good personal hygiene. Avoid transferring material from hands to mouth while eating, drinking, or smoking.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

STORAGE SEGREGATION: Store potassium away from sources of heat, ignition (sparks and open flames), water, combustible materials, and other chemical liquids. Store it away from oxidizers and acids. SPECIAL HANDLING/STORAGE: Protect containers against physical damage and shocks. Store this material in airtight containers under an inert atmosphere such as nitrogen or argon or in naphtha or another similar liquid hydrocarbon such as coal oil or kerosene. Never store under halogenated hydrocarbons such as Freon® or methylene chloride. An isolated, well-ventilated, fire-resistant building is recommended for large-quantity storage. Do not store where automatic sprinklers are present or where water or steam is available. Provide enough heat in the storage area to keep the material sufficiently dry. Provide enough appropriate fire extinguishers for storage area. COMMENTS: Remove only that amount of potassium which is immediately needed from the storage area. Use a metal container with a tight-fitting lid for transport. To prevent the formation of peroxide and oxide (an explosion hazard), follow manufacturer's shelf-life recommendations. Do not take this material out of your work area or to your home on your clothing or equipment. Dispose of containers and clean up work area adequately.
TRANSPORTATION DATA (per 49 CFR 170.101-2):
DOT Required Label: Flammable Solid and Dangerous When Wet
DOT ID No. UN2257
DOT Hazard Class: Flammable Solid; Dangerous When Wet
DOT Shipping Name: Potassium Metal
ADDITIONAL DOT REQUIREMENTS: Segregation is the same as for flammable solids labeled Dangerous When Wet.
References: 1-12, 18, 24, 37, 39, 44, 73, 82, 84, 87-102. OW

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Indust. Hygiene/Safety DW 11-18-87
Medical Review B Feldsmith 11-30-87

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Material Safety Data Sheets Collection:
Sheet No. 23
Cadmium Metal/Powder
Issued: 9/77 Revision: D, 5/93

Section 1. Material Identification

Cadmium Metal/Powder (Cd) Description: Occurs naturally in the mineral greenockite (cadmium sulfide). This form is rare and most cadmium is obtained by extraction from other ores containing it as a mineral (lead, copper, and zinc). Zinc sulfide ores are the main source; by direct distillation or recovery from the electrolytic process. Used in electroplating other metals, fire protection systems, nickel-cadmium storage batteries, power transmission wire, TV phosphors, pigments for ceramic glazes, machinery enamels, baking enamels, photography and lithography, selenium rectifiers, electrodes for cadmium-vapor lamps, and photoelectric cells; as a fungicide and a Weston standard cell control of atomic fission in nuclear reactors.

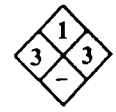
Other Designations: CAS No. 7440-43-9, colloidal cadmium.

Manufacturer: Contact your supplier/distributor. Consult latest *Chemical Week Buyers' Guide*[73] for suppliers list.

Cautions: Cadmium is a highly toxic metal. Symptoms may be delayed several hours and include pulmonary edema (fluid in lungs) which can be fatal. Chronic effects include kidney damage. Cd is considered a carcinogen by several government agencies. The powder is pyrophoric and presents a significant fire/explosion hazard.

Powder

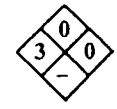
HMIS			
H	3*	R	3
F	1	I	4
R	3	S	2
		K	3



Genium

Solid

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



*Chronic effects PPE-Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Cadmium, ca 100%

1992 OSHA PEL
8-hr TWA: 5 $\mu g/m^3$

1992 OSHA SECAL*
TWA: 15 or 50 $\mu g/m^3$

1990 IDLH Level
50 mg/m^3

1993-94 ACGIH TLVs
TWA: 0.01 mg/m^3 (total dust), Class A2 carcinogen
TWA: 0.002 mg/m^3 (respirable fraction)

1991 DFG (Germany) MAK
None established

1992 NIOSH REL
Carcinogen, keep as low as possible

1992 Toxicity Data†
Human, inhalation, LC_{Lo}: 39 mg/m^3/20 min caused cardiac changes, thrombosis, and respiratory depression.
Rat, oral, LD_{50}: 225 mg/kg; details not reported.
Woman, inhalation, LC_{Lo}: 129 $\mu g/m^3$ for 20 continuous years produced lung tumors.
Man, TC_{Lo}: 88 $\mu g/m^3$/8.6 years caused kidney and ureter toxicity with protein in the urine.

* Separate engineering control limit: to be achieved in processes and work places where it is not possible to achieve the PEL through engineering and work practices alone. The SECAL for Cd is 15 or 50 $\mu g/m^3$ depending on the processes involved. See Federal Register 57 (178): 42222, Table VIII-B1, 9/14/92.
†See NIOSH, *RTECS* (EU9800000), for additional mutation, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 1409 °F (765 °C)
Melting Point: 610 °F (321 °C)
Vapor Pressure: 0.095 mm Hg at 609.6 °F (320.9 °C)
Refraction Index: 1.13
Mohs Hardness: 2.0
Molecular Weight: 112.4
Density: 8.642
Water Solubility: Insoluble
Other Solubilities: Soluble in nitric (rapidly), hydrochloric (slowly), and other acids. The solid is soluble in ammonium nitrate solution, but the powdered form undergoes an explosive reaction.

Appearance and Odor: Silver-white, blue-tinged, lustrous, odorless, soft metal that is easily cut with a knife. The powder is grayish-white.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: The solid metal is not flammable, but the finely divided powder is pyrophoric. As a rule, the more finely divided the powder is, the greater the potential for explosion. Use carbon dioxide, dry chemical, or sand. **Unusual Fire or Explosion Hazards:** Processes that create cadmium dust such as cutting, grinding, or welding present a serious explosion hazard in presence of ignition sources. Avoid creation of cadmium dust clouds. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Do not release runoff from fire control methods to sewers or waterways; dike for proper disposal.

Section 5. Reactivity Data

Stability/Polymerization: Cadmium easily tarnishes in moist air as it is oxidized to cadmium oxide. The solid is stable in dry air. The powder is pyrophoric. Cd becomes brittle at 176 °F (80 °C). Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include ammonium nitrate (powdered Cd), hydrazoic acid, tellurium, zinc, ammonia, sulfur, selenium, nitryl fluoride, an oxidizing agents. **Conditions to Avoid:** Creation of Cd dust clouds, exposure to heat and ignition sources, and contact with incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of Cd can produce toxic cadmium oxide (CdO) fumes.

Section 6. Health Hazard Data

Carcinogenicity: The following agencies list Cd as a carcinogen: IARC Class 2A (probably carcinogenic in humans),[183] NTP Class 2 (reasonably anticipated to be a carcinogen),[169] and NIOSH Class X (carcinogen defined without further categorization),[183] ACGIH TLV-A2 (suspected human carcinogen),[183] EPA-B1 (Probable human carcinogen) and DFG MAK-A2 (unmistakably carcinogenic in animal experimentation only).[183]
Summary of Risks: Dust or fume inhalation generally results in acute symptoms delayed up to 24 hr. Effects include a flu-like syndrome similar to metal fume fever with chills, fever, and muscle pain in the back and limbs. Pulmonary edema (fluid in lungs) can develop after severe exposure and may result in death. If victim recovers, residual changes may include lung fibrosis (thickening) and vascular changes. Long-term exposure to Cd damages the liver and kidneys (accumulates, half-life = 7 to 30 yr). Proteinuria (protein in urine) of low molecular weight is the first sign of tubular dysfunction. Excess urinary glucose is also seen. Bone demineralization similar to osteoporosis (decreased bone density)...

Continue on next page

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Section 6. Health Hazard Data, *continued*

occurs *not* as a direct effect of Cd exposure, but indirectly by altering kidney regulation of calcium and phosphorus which are needed for strong, healthy bones. Some studies show a correlation between anemia (low hemoglobin in blood) and high Cd levels. Selenium (Se) and zinc (Zn) appear to suppress Cd toxicity; Se binds up Cd preventing it from entering body tissue and Zn may compete for the same metabolic site. **Medical Conditions Aggravated by Long-Term Exposure:** Kidney, blood, or respiratory disorders. **Target Organs:** Blood, kidney, liver, respiratory system. **Primary Entry Routes:** Inhalation, ingestion. **Acute Effects:** Inhalation may cause irritation of the eyes, nose, and throat, nausea and vomiting, abdominal colic, diarrhea, chest tightness, cough, headache, and weakness. Pulmonary edema could develop up to 24 hr post exposure. Kidney damage may occur after acute exposures but is more likely with chronic exposure. **Chronic Effects:** Symptoms may be delayed several yr after last exposure and include perforation of the nasal septum (tissue between the nostrils), loss of smell, chronic bronchitis, severe progressive emphysema, anorexia, insomnia, fatigue, pallor, anemia, kidney damage, bone demineralization, lung fibrosis and possible cancer of the respiratory tract.

FIRST AID

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin: *Quickly* remove contaminated clothing. Wash exposed area with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of cadmium's irritating nature.

Note to Physicians: ß-2 microglobulin excretion of > 200 µg/g creatinine indicates kidney dysfunction as does a renal cortex [Cd] of 180 to 220 µg/g of wet kidney cortex. Blood Cd levels are *not* indicative of exposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against inhalation. Carefully scoop up small spills and place in sealed impermeable containers. *Do not* disperse dust by sweeping. Remember that Cd powder can be pyrophoric and must be handled carefully. Prevent entry into sewers, drains, and waterways. Follow applicable OSHA regulations (29 CFR 1910.120).

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.24): D006, Characteristic of Toxicity; regulatory level = 1.0 mg/L

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 10 lb (4.54 kg)† [* per CWA, Sec. 307(a)]

SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1027)

† No reporting of releases of this substance is required if the diameter of the pieces of the solid metal is equal to or exceeds 100 µm (0.004 in.)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use a SCBA or supplied air respirator (with auxiliary SCBA) with a full facepiece operated in pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear gloves, boots, aprons, and gauntlets to prevent Cd dust from contacting skin. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL or SECAL (Sec. 2). Lunchroom facilities should not have concentrations above 2.5 µg/m^3 at any time. Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes; launder before reuse. Remove Cd from shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using Cd, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage/Handling Requirements: Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles. Do not allow cadmium dust to build up in storage area.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level.

Administrative Controls: Prohibit workers from removing Cd from protective clothing and equipment by blowing, shaking, or any other means that disperses Cd into the air. Employees must not enter eating facilities while wearing PPE unless it is vacuumed with a HEPA. Consider preplacement and periodic medical exams of exposed workers emphasizing the blood, kidneys, liver, and respiratory system. Educate workers on Cadmium's carcinogenicity.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Poisonous solids, n.o.s.*, Pyrophoric metals, n.o.s.†
DOT Hazard Class: 6.1*, 4.2†
ID No.: UN2811*, UN1383†
DOT Packing Group: III*, I†
DOT Label: Keep away from food*, Spontaneously Combustible†
Special Provisions (172.102): —*, B11†

Packaging Authorizations
a) **Exceptions:** 173.153*, None†
b) **Non-bulk Packaging:** 173.213*, .187†
c) **Bulk Packaging:** 173.240*, 242†

Quantity Limitations
a) **Passenger Aircraft or Railcar:** 100 kg*, Forbidden†
b) **Cargo Aircraft Only:** 200 kg*, Forbidden†

Vessel Stowage Requirements
a) **Vessel Stowage:** A*, D†
b) **Other:**

* Solid metal, † Powder

***MSDS Collection* References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 148, 159, 167, 169, 183, 185, 186

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** TW Thoburn, MPH, MD

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Material Safety Data Sheet Collection

Mercury **MSDS No. 26**

Date of Preparation: 1/77 Revision: D, 6/94

Section 1 - Chemical Product and Company Identification 44

Product/Chemical Name: Mercury
Chemical Formula: Hg
CAS No.: 7439-97-6
Synonyms: colloidal mercury, hydrargyrum, liquid silver, Quicksilver
Derivation: Obtained by roasting cinnabar (mercury sulfide) and purified by distillation, or as a by-product of gold mining.
General Use: Used in agricultural poisons, anti-fouling paint, dental amalgams, mining amalgamation (to remove gold and other metals from ore), thermometers, barometers, dry cell batteries, chlorine and caustic soda production, electrical apparatus, and as a neutron absorber in nuclear power plants.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Mercury, ca 100 %wt

OSHA PEL
Ceiling: 0.1mg/m^3 (vapor and inorganic Hg)
8-hr TWA: 0.05 mg/m^3 (vapor), skin; (Vacated 1989 Final Rule Limit)

ACGIH TLVs
TWA: 0.025 mg/m^3 (inorganic compounds), skin

NIOSH REL
10-hr TWA: 0.05 mg/m^3 (vapor), skin

DFG (Germany) MAK
TWA: 0.01 ppm (0.1 mg/m^3)
Category III: Substances with systemic effects
Onset of Effect: > 2 hr
Half-life: > shift length (strongly cumulative)

Peak Exposure Limit:
0.1 ppm (1 mg/m^3), 30 min. average value, 1/shift

IDLH Level
28 mg/m^3

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Mercury exists as a heavy, odorless, silver-white liquid metal. It is highly toxic by both acute and chronic exposure. Exposure can cause corrosion of the eyes, skin, and respiratory tract and may result in irreversible nervous system damage. It readily forms amalgamations with most metals except iron.

Wilson Risk Scale	
R	1
I	4
S	2*
K	1

*Skin absorption

HMIS	
H	4*
F	0
R	0

*Chronic effects
PPE†
†Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, eye and skin contact/absorption.
Target Organs: Central nervous system, eyes, skin, respiratory system, liver, kidneys.
Acute Effects
Inhalation: Exposure to high vapor concentrations can cause severe respiratory damage. Other symptoms include wakefulness, muscle weakness, anorexia, headache, ringing in the ear, headache, diarrhea, liver changes, fever, gingivitis, chest pain, difficulty breathing, cough, inflammation of the mouth (stomatitis), salivation, bronchitis, and pneumonitis. Acrodynia (pink or Swifts disease), characterized by redness and peeling of the skin on the toes and fingers, was commonly seen in children in the 1950s and is still *infrequently* seen in workers.
Eye: Irritation and corrosion.
Skin: Skin can become severely irritated if allowed to remain in contact with mercury. Skin absorption will occur at 2.2% of the rate of absorption through the lungs.
Ingestion: Mercury generally passes through the digestive tract uneventfully. However, large amounts may get caught up in the intestine and require surgical removal. If an abscess or other perforation is present along the digestive tract, absorption into the blood stream with subsequent mercury poisoning is possible.
Carcinogenicity: IARC, NTP, and OSHA do not list mercury as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: Central nervous system disorders.
Chronic Effects: Chronic exposure appears more common than acute and is primarily associated with central nervous system damage which can be permanent (ex. paresthesia of the hands, lips, feet). Early signs of toxicity include weakness, fatigue, anorexia, weight loss, and gastrointestinal disturbances. If exposure levels are high, characteristic tremors of the fingers, eyelids, and lips occur with progression to generalized tremors of the entire body. Psychic disorders are noticeable and characterized by behavior and personality changes, increased excitability, memory loss, insomnia, and depression. In severe cases, delirium and

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hallucinations may occur. Kidney damage is observed with oliguria (decreased urine output) progressing to anuria (urine cessation) and may require dialysis. The cornea and lens of the eyes may take on a brownish discoloration and the extraocular muscles may be damaged. This syndrome has been termed *Asthenic-Vegetative Syndrome* or *Micromercurialism.* Chronic symptoms occur increasingly with exposures to 0.1 mg/m^3 or higher. *Mutation:* Aneuploidy and other chromosomal aberrations have been observed in the lymphocytes from whole blood cultures in workers exposed to mercury. *Reproductive:* Mercury has been detected in stillborn babies of women treated with mercury for syphilis. In a study of six men acutely exposed (occupationally) to mercury levels as high as 44 mg/m^3, all suffered impaired sexual function. Repeated skin contact may cause allergic dermatitis in some individuals.

NOTE: Spilled mercury will release sufficient vapor over time to produce chronic poisoning.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

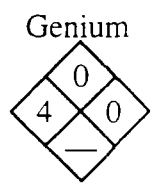
Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water and then wash exposed area with soap. For reddened or blistered skin, consult a physician.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. In general, mercury will pass through the digestive tract uneventfully.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: BEI: *blood* (15 µg/L), *urine*: (35 µg/g creatinine). Extremely high urine levels of 0.5 to 0.85 mg Hg/L are indicative of polyneuropathy. 0.4 to 22 µg/L is reported to be the human lethal blood level. Obtain urinalysis including at a minimum: albumin, glucose, and a microscopic examination of centrifuged sediment. Use BAL or 2, 3-dimercaptosuccinic acid as chelators. *Do not* use calcium sodium EDTA because of nephrotoxicity. An electromyograph may determine extent of nerve dysfunction. It has been noted that exposure to mercury may predispose persons to development of carpal tunnel syndrome.

Section 5 - Fire-Fighting Measures



Flash Point: Nonflammable

Autoignition Temperature: Nonflammable

LEL: None reported.

UEL: None reported.

Extinguishing Media: Use agents suitable for surrounding fire.

Unusual Fire or Explosion Hazards: None reported.

Hazardous Combustion Products: Toxic mercury vapor and mercuric oxide.

Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways.

Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Keep a mercury spill kit readily available in areas where mercury is used. Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind.

Small and Large Spills: Follow instructions on mercury spill kit. Most kits come with an aspiration-driven vacuum trap with a mercury "sweeper" (copper or copper-plated brush). Wash spill area with a dilute calcium sulfide or nitric acid solution. If spill cannot be taken up readily, dust the top of the spill with flowers of sulfur or preferably, calcium polysulfide. This will produce a surface coating of mercury sulfide which will reduce mercury vapor dispersion into the air.

Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Use appropriate PPE when working with mercury. *Do not* use on porous work surfaces (wood, unsealed concrete, etc.) to prevent spills from lodging in cracks.

Storage Requirements: Store in a cool, dry, well-ventilated area away from heat and incompatibles (Sec. 10). Store on non-porous floors and wash them regularly with a dilute calcium sulfide solution. Because mercury will form amalgamations with most metals except iron, metal shelves should be painted with a sufficiently thick coating to prevent this from happening.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Wherever possible, enclose processes to prevent mercury vapor dispersion into work area.

Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103)

Administrative Controls: Consider pre-placement and periodic medical exams of exposed workers with emphasis on the skin, eyes, central nervous system, liver, and kidneys.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For $\leq$ 0.5 mg/m^3, use any chemical cartridge

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respirator with cartridges providing protection against mercury and equipped with an ESLI (end of service life indicator), any SCBA, or any SAR (supplied-air respirator). For ≤ 1.25 mg/m^3, use any SAR operated in continuous-flow mode, any PAPR (powered, air-purifying respirator) with an ESLI. For ≤ 2.5 mg/m^3, use any SCBA or SAR with a full facepiece, any SAR with a tight-fitting facepiece and operated in continuous-flow mode, or any chemical cartridge respirator with a full facepiece, chemical cartridges providing protection against mercury, and equipped with an ESLI. For ≤28 mg/m^3, use any SAR operated in pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA with full facepiece and operated in pressure-demand or other positive pressure mode. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber, nitrile rubber, fluorocarbon rubber, neoprene rubber, polyvinyl chloride, chlorinated polyethylene, or polycarbonate to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Liquid metal
Appearance and Odor: Silvery-white, odorless
Vapor Pressure: 0.0018 mm Hg at 77 °F (25 °C)
Formula Weight: 200.59
Density (H_2O=1): 13.534 g/cm^3 at 77 °F (25 °C)
Boiling Point: 674.09 °F (356.72 °C)
Freezing Point: -37.97 °F (-38.87 °C)
Viscosity: 15.5 mP at 77 °F (25 °C)
Electrical Resistivity: 95.76 µohm at 68 °F (20 °C)

Water Solubility: 0.28 µmol/L at 77 °F (25 °C)
Other Solubilities: Soluble in boiling sulfuric acid, nitric acid (reacts); slightly in lipids, and 2.7 mg/L in pentane. Insoluble in alcohol, ether, cold sulfuric acid, hydrogen bromide, and hydrogen iodide.
Surface Tension: 484 dyne/cm at 77 °F (25 °C)
Critical Temperature: 2664 °F (1462 °C)
Critical Pressure: 1587 atm

Section 10 - Stability and Reactivity

Stability: Mercury does not tarnish at ordinary temperatures but when heated to near its boiling point, it slowly oxidizes to mercuric oxide.

Polymerization: Hazardous polymerization does not occur.

Chemical Incompatibilities: Mercury forms alloys (amalgamates) with most metals except iron. It is incompatible with oxidizers such as bromine, 3-bromopropyne, methylsilane + oxygen, chlorine, chlorine dioxide, nitric acid, or peroxyformic acid; tetracarbonyl nickel + oxygen, alkynes + silver perchlorate, ethylene oxide, acetylenic compounds (explosive), ammonia (explosive), boron phosphodiiodide, methyl azide, nitromethane, and ground sodium carbide.

Conditions to Avoid: Exposure to high temperatures, metal surfaces or incompatibles.

Hazardous Decomposition Products: Thermal oxidative decomposition of mercury can produce mercuric oxide.

Section 11- Toxicological Information

Toxicity Data:*

Reproductive:
Rat, inhalation: 890 ng/m^3/24 hr for 16 weeks prior to mating had an effect on spermatogenesis.

Acute Dermal Toxicity:
Man, skin, TD_{Lo}: 129 mg/kg for 5 continuous hours caused ringing in the ears, headache, and allergic dermatitis.

Acute Oral Toxicity:
Man, oral, TD_{Lo}: 43 mg/kg caused tremor and jaundice or other liver changes.

Acute Inhalation Effects:
Woman, inhalation, TC_{Lo}: 150 µg/m^3/46 days caused anorexia, diarrhea, and wakefulness.
Man, inhalation, TC_{Lo}: 44300 µg/m^3/8 hr caused muscle weakness, liver changes, and increased body temperature.

Chronic Effects:
Rat, inhalation: 1 mg/m^3/ 24 hr for 5 continuous weeks caused proteinuria.

* See NIOSH, *RTECS* (OV4550000), for additional toxicity data.

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Section 12 - Ecological Information

Ecotoxicity: Catfish, LC_{50} = 0.35 mg/L/96 hr; mollusk (*Modiolus carvalhoi*), LC_{50} = 0.19 ppm/96 hr: tadpole (*Rana hexadactyla*), LC_{50} = 0.051 ppm/96 hr. Mercury is transformed to methyl mercury by bacteria in the environment and undergoes bioaccumulation readily. BCF for freshwater fish = 63,000; for saltwater fish = 10,000; and for marine and freshwater invertebrates = 100,000.

Environmental Degradation: Mercury is expected to volatilize rapidly when deposited on soil surfaces. Once in the air, it can be transported long distances before being redeposited on soil or in water. In water, mercury appears to bind to particulates where it eventually becomes deposited on the bed sediment. In general, mercury entering the environment can be deposited and revolatilized several times.

Section 13 - Disposal Considerations

Disposal: Incineration is *not* an appropriate disposal method. Wastewater may be treated by addition of chlorine to oxidize the mercury to its ionic state. The water can then be passed through an absorbent (an activated charcoal concentrate with a sulfur coating or peanut shell charcoal) to collect the ionic mercury, followed by distillation to recover the mercury. Sodium borohydride, a reducing agent, can be used to precipitate mercury from waste solutions. Bioremediation, using *Pseudomonas putida*, has also been suggested. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Mercury
Shipping Symbols: A, W
Hazard Class: 8
ID No.: UN2809
Packing Group: III
Label: Corrosive
Special Provisions (172.102): –

Packaging Authorizations
a) Exceptions: 173.164
b) Non-bulk Packaging: 173.164
c) Bulk Packaging: 173.240

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 35 kg
b) Cargo Aircraft Only: 35 kg

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: 40, 97

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste (40 CFR 261.33): U151
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per RCRA, Sec. 3001; CWA, Sec. 307(a), CAA, Sec. 112
CERCLA Reportable Quantity (RQ), 1 lb (0.454 kg)
SARA 311/312 Codes: 1, 2
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 73, 103, 124, 132, 136, 148, 149, 159, 167, 176, 187, 189

Prepared By ..... M Gannon, BA
Industrial Hygiene Review ..... RE Langford, PhD, CIH
Medical Review ..... T Thoburn, MD, MPH

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Material Safety Data Sheets Collection:

Sheet No. 59
Beryllium Metal/Powder

Issued: 4/80 Revision: A, 11/89

Section 1. Material Identification

30

Beryllium Metal/Powder Description: A naturally occurring ore found in chrysoberyl (Be_2SiO_4) or produced industrially from beryl ($3BeO.Al_2O_3.6SiO_2$). The ore is converted to the oxide or hydroxide, then to the fluoride or chloride. The halide may be reduced in a furnace by magnesium metal or by electrolysis. An alternative purification process is a liquid-liquid extraction with an organophosphate chelating agent. Used in aerospace structures, radio tube parts, inertial guidance systems, computer parts, Be-Cu alloys, gyroscopes; used as an additive in solid propellant rocket fuels, as a neutron source when bombarded with alpha particles, and as a neutron moderator and reflector in nuclear reactors.
Other Designations: Glucinium; Be; CAS No. 7440-41-7.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

R	1
I	4
S	2
K	1

Genium

HMIS
H 4
F 1
R 0
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Beryllium and compounds, ca 100%

OSHA PELs
8-hr TWA: 0.002 ppm
30-min STEL: 0.005 ppm
Ceiling level: 0.025 ppm

ACGIH TLV, 1989-90*
TLV-TWA: 0.002 mg/m³

NIOSH REL, 1987*
Not to exceed 0.5 µg/m³

Toxicity Data†
Human, inhalation, TC_{Lo}: 300 mg/m³, pulmonary effects
Rabbit, intravenous, TD_{Lo}: 20 mg/kg, neoplastic effects

* These values are for beryllium and its compounds.
† See NIOSH, *RTECS* (DS1750000), for additional data with references to mutagenic and tumorigenic effects.

Section 3. Physical Data

Boiling Point: 5378 °F (2970 °C)
Melting Point: 2332 °F (1278 °C)
Vapor Pressure: 7.6 mm Hg at 3470 °F (1910 °C)
Atomic Weight: 9.01 g/mol

Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 1.848 at 68 °F (20 °C)
Water Solubility, hot water: Slight
cold water: Insoluble

Appearance and Odor: A grayish-white metal with a hexagonal and aniostropic crystal structure (i.e., their index of refraction varies with incident light direction), and a powdered metal, no odor.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** Powder, ca 1200 °F (649 °C)	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: *Never* use water or CO_2. Instead, smother the fire with an approved dry-powder extinguisher. Sand, graphite powder, and sodium chloride are also recommended.
Unusual Fire or Explosion Hazards: Beryllium can be a moderate fire hazard if exposed to flame. The hazards increase as particulate size decreases. A beryllium dust cloud can be explosive (areas where dusting may occur require Class 2, Group E electrical services, 29 CFR 1910.309). This material's combustion products are *highly toxic*.
Special Fire-fighting Procedures: Fire fighters should use full protective clothing, eye protection, and a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. After exposure to a beryllium fire, they should clean equipment and bathe carefully.

Section 5. Reactivity Data

Stability/Polymerization: Beryllium is stable at room temperature in closed containers.* Hazardous polymerization cannot occur.
Chemical Incompatibilities: Acid and alkali soluble, it reacts with strong bases to evolve hydrogen.† Warm beryllium reacts incandescently with phosphorus, fluorine, or chlorine. Molten lithium metal at 356 °F (180 °C) severely attacks beryllium metal.
Conditions to Avoid: When heated in air or in mixed CO_2 and nitrogen, beryllium is ignitable. Mixtures of the powdered metal with CCl_4 or trichloroethylene flash on heavy impact.
Hazardous Products of Decomposition: Thermal oxidative decomposition of beryllium emits very toxic oxide of beryllium fumes.

* When moist, beryllium forms thin, acid-resistant oxide films on solid surfaces.
† A simple asphyxiant gas, hydrogen is extremely flammable.

Section 6. Health Hazard Data

Carcinogenicity: The NTP, IARC, and ACGIH list beryllium as a carcinogen. Animal studies also indicate that beryllium produces lung and bone tumors.
Summary of Risks: Beryllium is highly toxic by inhalation of fume or dust and exposure to this element and its salts may cause death. Inhaled beryllium is partially deposited in the lungs, the blood system, and finally the bones, thus affecting all organ systems. Since the human body does not quickly eliminate beryllium, trace amounts in urine are detectable as long as 10 years after exposure. Prolonged or repeated skin contact can cause skin irritation or dermatitis. Eye contact can produce conjuctivitis and eye ulcers. If introduced through the skin via cuts or punctures, nonhealing ulcers may develop.

Continue on next page

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Section 6. Health Hazard Data, continued

Medical Conditions Aggravated by Long-Term Exposure: Increased risk of lung, liver, gall bladder, and bile duct cancers. **Target Organs:** Lungs, mucous membranes, eyes, skin. **Primary Entry:** Inhalation. **Acute Effects:** Symptoms may occur up to 72 hr after a massive exposure. Acute inhalation can produce pneumonitis with inflammation of the upper and lower respiratory tracts, nasal congestion, nonproductive coughing, and pulmonary edema. High dose exposures may cause acute respiratory distress, brain hemorrhaging, liver inflammation, and spleen hemorrhaging. **Chronic Effects:** Symptoms may be delayed up to 15 years. Chronic exposures result from long-term exposure to small (microgram) quantities and can produce berylliosis. Berylliosis is a progressive granuloma formation in the lungs which eventually causes increasing shortness of breath and, in some cases, death. Since it also circulates among other organs, beryllium causes eventual heart enlargement and failure, liver and spleen enlargement, kidney stones, various malignant tumors, and damaging cell death in any organ in which it accumulates.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min. **Skin:** After rinsing affected area with flooding amounts of water, wash it with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. If ingested, have that conscious person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear. Present studies indicate that beryllium is so poorly absorbed through the intestinal tract, that ingestion is not an important hazard (*Industrial Toxicology*, 3rd Edition, Hamilton). **After first aid, get appropriate in-plant, paramedic, or community medical attention and support.** Watch for signs of respiratory deterioration, and use oxygen as needed.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: If powdered metal is spilled, notify safety personnel. Evacuate area except for cleanup personnel with protective equipment against contact or inhalation hazards. Provide ventilation and remove heat and ignition sources. To prevent dusting conditions, vacuum or wet mop powder spills. Collect particulate scrap, absorb on paper, and transfer to a sealed recovery or disposal container. **Disposal:** Dissolve beryllium in a small amount of 6M-HCl, filter it, and add a slight excess of 6M-NH_4OH to the filtrate using litmus as an indicator (blue at pH 8.3). Heat and coagulate the precipitate. After 12 hr, filter and dry it. Handle beryllium waste unsuitable for recycling in accordance with Federal, state, and local regulations. Dispose of scrap or waste material by arranging its return to the supplier in a mutually acceptable form. Contact your supplier or a licensed contractor for detailed recommendations.

OSHA Designations

Listed as Air Contaminant (29 CFR 1910.1000, Table Z-2)

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per RCRA, Sec. 3001; per Clean Water Act, Sec. 307(a), 112]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Wear a NIOSH-approved respirator for emergency and nonroutine use in concentrations above the 8-hr, 2-μg/m³ TWA. For any time period, a half-mask, air-purifying respirator with a high-efficiency filter is suitable for concentrations as high as 25-μg Be/m³ (see NIOSH, *A Recommended Standard for Occupational Exposure to Beryllium*, Sec. 4). A powered, air-purifying respirator equipped with a "fume filter" is suitable for concentrations up to 40 μg Be/m³. A full facepiece, air-purifying respirator with a high-efficiency filter is suitable for concentrations up to 100 μg Be/m³. A powered, air-purifying respirator equipped with a high-efficiency filter, operating in the positive-pressure mode, is suitable for concentrations up to 1000 μg Be/m³. An SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode is suitable for concentrations above 1000 μg Be/m³. Follow OSHA respirator regulations (29 CFR 1910.134). **Warning:** Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. When exposure levels exceed the TLV, change into clean protective clothing and shower at the end of your shift. **Ventilation:** Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL standards (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 103). **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Launder contaminated clothing before wearing. Remove this material from your shoes and equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Clearly label and store beryllium away from incompatible materials (Sec. 5) in a clean, dry, low fire-hazard area. Protect containers from physical damage. **Engineering Controls:** Provide adequate ventilation in areas where beryllium can become airborne. Monitor these areas with personal samplers to limit and control exposure levels. Teach workers about beryllium's potential hazards. Practice good housekeeping to prevent accumulation of beryllium-containing deposits. Give preplacement and annual medical exams (chest x-rays, baseline pulmonary function tests [FVC_1 (functional vital capacity) and FEV_1 (the amount of air exhaled in the first second after maximum inhalation)] and body weight measurements to workers possibly exposed to concentrations above the TLV. Prevent exposing those with pulmonary disease, chronic skin, liver, heart, or kidney conditions; abnormal chest x-ray or blood count; or vital capacity depression greater than 10%. Ensure all engineering systems (production, transportation) are of maximum explosion-proof design. To prevent static sparks, electrically ground and bond all containers and pipelines used in shipping, transferring, reacting, producing, and sampling operations.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Beryllium compound, n.o.s.
DOT Hazard Class: Poison B
DOT ID No.: UN1567

IMO Shipping Name: Beryllium, metal powder
IMO Hazard Class: 6.1
IMO Label: Poison, flammable solid

MSDS Collection **References:** 1-12, 18-20, 24-26, 81, 84, 85, 88-91, 100, 116, 117

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** Warren Silverman, MD F6

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Material Safety Data Sheets Collection:

Sheet No. 70
Antimony Metal/Powder

Issued: 9/80 Revision: A, 11/89

Section 1. Material Identification

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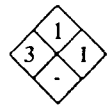
Antimony Metal/Powder Description: A naturally occurring ore found in sulfides, oxides, complex lead, silver, copper, and mercury sulfides. Prepared in the laboratory by reducing Sb_2O_5 with KCN. Used in manufacturing bullets, bearing metal, hard lead, blackening iron, coating metals, white metal, thermoelectric piles, storage batteries, cable sheaths, type metal, and alloys (Britannia or Babbitt metal). Pure antimony compounds are used as catalysts in organic synthesis, abrasives, plasticizers, pigment, and flameproofing compounds; also used in manufacturing paints, enamels, matches, glass, pharmaceuticals, explosives, and tartar emetic.

Other Designations: Stibium; antimony regulus; Sb; CAS No. 7440-36-0.

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

R 1
I 3
S 3
K 1

Genium



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PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Antimony, ca 99%

OSHA PEL
8-hr TWA: 0.5 mg/m³ (as Sb)

ACGIH TLV, 1989-90
TLV-TWA: 0.5 mg/m³ (as Sb)

NIOSH REL, 1987*
10-hr TWA: 0.5 mg/m³

Toxicity Data†
Rat, intraperitoneal, LD_{50}: 100 mg/kg
Rat, oral, LD_{50}: 100 mg/kg

* NIOSH has proposed a 10-hr TWA of 0.5 mg/m³ with an action level at 0.25 mg/m³. The TLV was established at a level to prevent irritation and systemic effects.
† See NIOSH, *RTECS* (CC4025000), for additional data with references to toxic effects.

Section 3. Physical Data

Boiling Point: 2975 °F (1635 °C)
Melting Point: 1166.9 °F (630.5 °C)
Vapor Pressure: 1 mm Hg at 1627 °F (886 °C)
Molecular Weight: 121.76 g/mol

Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 6.68 at 77 °F (25 °C)
Water Solubility: Insoluble
Mohs Hardness: 3.0 to 3.5

Appearance and Odor: A brittle, flaky, crystalline solid with a lustrous blue-white color; however, a noncrystalline form is also known. The powder form is dark gray, lustrous.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** Cloud,* 788 °F (420 °C); dust layer,* 626 °F (330 °C)	**LEL:** Dust cloud explosion, 0.42 oz/ft³	**UEL:** None reported

Extinguishing Media: Dry chemical powder.

Unusual Fire or Explosion Hazards: Antimony bulk metal is combustible in air at *high temperature*. When ignited it burns with a brilliant flame, giving off dense, white antimony trioxide (Sb_2O_3) fumes. When exposed to heat or ignition sources, powdered antimony is a moderate fire and explosion hazard. Particle size and dispersion in air determine reactivity.

Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Personal protective clothing and eye protection are essential.

* Ninety-one percent of dust goes through a 74-μm sieve. A 1.92-J spark can ignite an antimony dust cloud.

Section 5. Reactivity Data

Stability/Polymerization: Antimony metal (bulk) is stable in dry air at room temperature in closed containers. It slowly tarnishes in moist air. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Antimony is not very reactive with cold, dilute acids, but it reacts readily with aqua regia and hot, concentrated sulfuric acid. Powdered antimony* also reacts with hot, concentrated hydrochloric acid (HCl). On contact with acid, it emits toxic antimony trihydride (SbH_3) fumes; electrolysis of acid sulfides and stirred antimony halide yields explosive antimony. Antimony can react vigorously or violently with oxidizing agents such as nitrate salts, halogens, nitric acid, perchloric acids, chlorine trifluoride (ClF_3), potassium permanganate ($KMnO_4$), ammonium nitrate (NH_4NO_3), bromine trinitride (BrN_3), bromine trifluoride (BrF_3), chlorine monoxide (ClO), chlorine trifluoride (ClF_3), potassium nitrate (KNO_3), sodium nitrate ($NaNO_3$), and potassium oxide (K_2O_2).

Conditions to Avoid: Nascent hydrogen can react with Sb, or its alloys with Mg or Zn, to form antimony trihydride, a colorless, highly toxic gas (causing headache, nausea, vomiting, abdominal pain, hemolysis (separation of hemoglobin from red blood corpuscles), hematuria (blood in the urine), and death) with a disagreeable odor (0.1-ppm TLV).

Hazardous Products of Decomposition: Thermal oxidative decomposition of antimony can produce toxic SbH_3 fumes.

* Powdered antimony reacts more vigorously than the bulk material and forms dangerous mixtures with oxidizing agents. Heating further increases its reactivity.

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists antimony as a carcinogen. However, its ore is a suspected carcinogen in antimony trioxide production. Antimony trioxide is prepared in the laboratory by a volatilization process involving antimony trichloride ($SbCl_3$) and water.
Summary of Risks: An irritant to mucous membranes, eyes, and skin. Exposures to dust/powder can cause eye inflammation (conjunctivitis), nasal irritation (rhinitis - perforation of the nasal septum), chronic dermatitis ranging from mild rashes to blemishes resembling chicken pox, and muscle pain and weakness. Some sources refer to antimony as a human poison by an unspecified route. Exposure to antimony may result in "metal fume fever," a flu-like syndrome with fever, fatigure, cough, and muscle ache.
Medical Conditions Aggravated by Long-Term Exposure: Chronic inhalation of subtoxic doses of dust or fume above the TLV may result in chemical pneumonia, intraalveolar lipid deposits, liver and cardiac involvement, and possible kidney disease.
Target Organs: Skin, eyes, mucous membranes, respiratory system, and cardiovascular system.
Primary Entry: Inhalation (dust and fume), ingestion.
Acute Effects: Acute ingestion may cause violent vomiting, diarrhea, slow pulse and low blood pressure, shallow breathing, and death.
Chronic Effects: Chronic exposures lead to dizziness, dry throat, sleeplessness, anorexia, and nausea.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: After rinsing affected area with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: ***Contact physician!*** Never give anything by mouth to an unconscious or convulsing person. Give 1 to 2 glasses of water to dilute, although vomiting may be spontaneous after ingestion.
After first aid, get appropriate in-plant, paramedic, or community medical attention and support.
Physician's Note: If indicated, intravenous gastric lavage chelation therapy with BAL (British Anti-Lewsite) for 10 days is recommended.

Spill/Leak: Notify safety personnel of powder spills. Small spills can be removed by vacuuming or wet sweeping to minimize airborne dust. Cleanup personnel should use protective equipment.
Disposal: Return scrap metal to your supplier. Unsalvageable waste may be buried in an approved secure landfill. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per Clean Water Act, Sec. 307(a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Wear a NIOSH-approved respirator if necessary. Follow OSHA respirator regulations (29 CFR 1910.134). Respirators should be available for nonroutine or emergency use for concentrations above the TLV: high-efficiency dust respirators for concentrations below 5 mg/m^3 and self-contained or air-supplied respirators with full facepiece for concentrations above 5 mg/m^3.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL standard (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 103).
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Launder contaminated clothing before wearing. Remove this material from your shoes and equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a dry, well-ventilated, low fire-risk area. Avoid heat and direct sunlight.
Engineering Controls: Avoid breathing dust or fumes. Practice good housekeeping and cleaning techniques to prevent dust accumulation and to minimize airborne particulates. Minimize skin contact by using barrier creams, rubber gloves and aprons, and good personal hygiene. Keep antimony dust off clothing. Provide preplacement and periodic medical examinations for those workers exposed regularly to antimony, with emphasis on the skin, mucous membranes, and the pulmonary, cardiac, and reproductive systems. Provide suitable training to those working with antimony. Monitor the workplace. Keep records.

Transportation Data (49 CFR 172.102)

IMO Shipping Name: Antimony compounds, inorganic, n.o.s.
IMO Hazard Class: 6.1
IMO Label: Poison/St. Andrews Cross (Stow away from foodstuffs)
IMDG Packaging Group: I, II, III

***MSDS Collection* References:** 1, 2-12, 24, 26, 27, 31, 37, 38, 41, 81, 84, 87, 89, 90, 91, 100, 109
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

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Material Safety Data Sheets Collection:

Sheet No. 311
Methyl Chloroform

Issued: 11/75 Revision: F, 3/92 Errata: 6/92

Section 1. Material Identification

38

Methyl Chloroform ($C_2H_3Cl_3$) Description: Derived by catalytic addition of hydrogen chloride to 1,1-dichloroethylene or by re-fluxing chlorine monoxide with carbon tetrachloride and chloroethane. Available in technical and solvent grades which differ only in the amount of stabilizer added to prevent metal parts corrosion. Used as a solvent for oils, waxes, tars, cleaning precision instruments, and pesticides; as a component of inks and drain cleaners; in degreasing metals, and textile processing. In recent years, methyl chloroform has found widespread use as a substitute for carbon tetrachloride.

R	1
I	2
S	2*
K	1

Genium

HMIS
H 2
F 1
R 1
PPG*
* Sec. 8

Other Designations: CAS No. 71-55-6, α-trichloroethane; Inhibisol; 1,1,1-trichloroethane; Strobane.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.
Cautions: Methyl chloroform is a skin, eye, and respiratory tract irritant and can become narcotic with an anesthetic effect at high concentrations.
* Data on skin absorption via methyl chloroform is conflicting.[133] Some studies show definite absorption where others don't.

Section 2. Ingredients and Occupational Exposure Limits

Methyl chloroform, ca 92 to 97%*

1990 OSHA PELs
8-hr TWA: 350 ppm (1900 mg/m³)
15-min STEL: 450 ppm (2450 mg/m³)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
15-min Ceiling: 350 ppm (1900 mg/m³)

1991-92 ACGIH TLVs
TWA: 350 ppm (1910 mg/m³)
STEL: 450 ppm (2460 mg/m³)

1990 DFG (Germany) MAKs
TWA: 200 ppm (1080 mg/m³)
Half-life: 2 hr to shift length
Peak Exposure Limit: 1000 ppm/30 min (average value)/2 per shift

1985-86 Toxicity Data†
Human, oral, TD_{Lo}: 670 mg/kg produced diarrhea, nausea, and vomiting
Human, inhalation, LC_{Lo}: 27 g/m³/10 min; toxic effects not yet reviewed
Man, eye: 450 ppm/8 hr produced irritation
Rat, inhalation, TC_{Lo}: 2100 ppm/24 hr for 14 days prior to mating and from 1 to 20 days of pregnancy produced specific developmental abnormalities of the musculoskelatal system

* Methyl chloroform usually contains inhibitors (3 to 8%) to prevent corrosion of aluminum and some other metals. Typical inhibitors are nitromethane, butylene oxide, secondary butyl alcohols, ketones, and glycol diesters.
† See NIOSH, *RTECS* (KJ2975000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 165 °F (75 °C)
Freezing Point: -22 °F (-30 °C)
Vapor Pressure: 100 mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 4.55
Corrosivity: Readily corrodes aluminum and its alloys
Refraction Index: 1.43765 at 69.8 °F (21 °C)
Viscosity: 0.858 cP at 68 °F (20 °C)
Molecular Weight: 133.42
Density: 1.3376 at 68/39.8 °F (20/4 °C)
Water Solubility: Insoluble
Other Solubilities: Soluble in acetone, alcohol, ether, benzene, carbon tetrachloride, and carbon disulfide
% in Saturated Air: 16.7% at 77 °F (25 °C)
Relative Evaporation Rate (butyl acetate = 1): 12.8
Appearance and Odor: Colorless liquid with a sweetish, chloroform-like odor. The odor threshold is 44 ppm.

Section 4. Fire and Explosion Data

Flash Point: None (in conventional CC tests)	Autoignition Temperature: 932 °F (500 °C)	LEL: 7% v/v	UEL: 16% v/v

Extinguishing Media: *Noncombustible liquid* whose *vapor* burns in the presence of excess oxygen or a strong ignition source. For small fires, use dry chemical or carbon dioxide (CO_2). For large fires use fog or regular foam. If these materials are unavailable, a water spray may be used but be aware that water reacts slowly with methyl chloroform to release hydrochloric acid.
Unusual Fire or Explosion Hazards: Vapors are heavier than air and may travel to a strong ignition source and flash back. Air/vapor mixtures may explode when heated. Container may explode in heat of fire. Exposure to open flames or arc welding can produce hydrogen chloride and phosgene.
Special Fire-fighting Procedures: Methyl chloroform's burning rate is 2.9 mm/min. Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides limited protection. Wear clothing specifically recommended by the manufacturer for use in fires involving methyl chloroform. Apply cooling water to container sides until after fire is extinguished. Stay away from ends of tanks. Isolate area for 1/2 mile if fire involves tank, truck, or rail car. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Methyl chloroform is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can occur in contact with aluminum trichloride.
Chemical Incompatibilities: Methyl chloroform is incompatible with sodium hydroxide, nitrogen tetroxide, oxygen (liquid or gas), strong oxidizers, and chemically active metals like aluminum, zinc, and magnesium powders; reacts violently with caustics to form dichloroacetylene; reacts slowly with water to form hydrochloric acid; forms shock sensitive mixtures with potassium; and polymerizes in contact with aluminum trichloride.
Conditions to Avoid: Exposure to moisture, strong ignition sources, and arc-welding units, and contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition (temperatures >500 °F, contact with hot metals, or under UV rays) of methyl chloroform can produce carbon dioxide (CO_2) and toxic dichloroacetylene, hydrogen chloride, and phosgene gases.

Section 6. Health Hazard Data

Carcinogenicity: The IARC (Class 3, inadequate evidence),[164] NTP,[142] and OSHA[164] do not list methyl chloroform as a carcinogen.
Summary of Risks: Methyl chloroform is considered one of the least toxic of the liquid chlorinated hydrocarbons. It is irritating to eyes, skin, and respiratory tract. Although low in systemic toxicity, methyl chloroform is an anesthetic capable of causing death at high concentrations (>15,000 ppm), generally in poorly ventilated, enclosed areas. Quick and complete recovery is observed after prompt removal of unconscious persons from area of exposure. Like many other solvents, methyl chloroform sensitizes the heart to epinephrine (blood pressure-raising hormone) and may induce cardiac arrhythmias and arrest.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, central nervous (CNS) and cardiovascular (CVS) systems.

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Section 6. Health Hazard Data, *continued*

Primary Entry Routes: Inhalation, skin contact. **Acute Effects:** Methyl chloroform defats the skin causing irritation, redness, dryness, and scaling. Contact with eyes produces irritation and mild conjunctivitis. Vapor inhalation can cause headache, dizziness, equilibrium disturbances, and in high concentrations may lead to CNS depression, unconsciousness, and coma. During a 60-min exposure period these effects are observed: 100 ppm is the observed odor threshold, at 500 ppm there is obvious odor and decreased reaction time, 1000 ppm causes slight equilibrium loss, at 5000 ppm there is definite incoordination, and 20,000 ppm produces surgical strength anesthesia with possible death. Mild liver and kidney dysfunction may occur after CNS depression recovery. Although unlikely, if ingestion occurs, symptoms include nausea, vomiting, diarrhea, and possible esophageal burns. The *acute lethal human dose is ~500 to 5000 mg/kg.* **Chronic Effects:** *None reported.*

FIRST AID

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.

Inhalation: Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center, and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. When deciding whether to induce vomiting, carefully consider amount ingested, time since ingestion, and availability of medical help. If large amounts are recently ingested (absorption into the body is not yet likely to have occurred), and medical help or transportation to a medical facility is not readily available, induce vomiting. Otherwise, vomiting is not recommended since aspiration of vomitus can produce chemical pneumonitis.

Note to Physicians: Do not use adrenaline or sympathomimetic amines in treatment because of the increased cardiac sensitivity involved.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources. If possible without risk, shut off leak. Cleanup personnel should wear fully encapsulating vapor-protective clothing. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material. Using nonsparking tools, place in suitable containers for disposal or reclamation. For large spills, dike far ahead of liquid spill for later disposal or reclamation. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120).

Environmental Transport: In water, methyl chloroform's half-life is hours to weeks depending on wind and mixing conditions. It is very persistent in groundwater. On land it volatilizes due to its high vapor pressure and leaches extensively. When released to the atmosphere, methyl chloroform can be transported long distances and returned to earth via rain. It is slowly degraded by reaction with hydroxyl radicals and has a half-life of 6 months to 25 years. The Natural Resources Defenses Council reported recently that methyl chloroform depletes ozone.

Ecotoxicity Values: *Pimephales promelas* (fathead minnow), LC_{50}: 52.8 mg/L/96 hr; *Poecilia reticulata* (guppy), LC_{50}: 133 ppm/1 day.

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U226

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 1000 lb (454 kg) [* per RCRA, Sec. 3001, CWA, Sec. 307(a), and CAA, Sec. 112]

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear splash-proof, protective chemical safety goggles or faceshields, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent repeated or prolonged skin contact. Viton and butyl rubber [with breakthrough times (BTs) of >8 hr and 4 to 7.9 hr, respectively] are recommended materials for protective gear. *Do not use* neoprene, polyvinyl chloride (PVC), natural rubber, or polyethylene because these materials have a BT of <1 hr.

Ventilation: Provide general and local exhaust (in some cases, explosion-proof) ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into work area by controlling it at its source.[103]

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in cool, dry, well-ventilated (use pressure-vacuum ventilation) area away from ignition sources, arc-welding operations, and incompatibles (Sec. 5). Regularly monitor inhibitor levels. *Do not* store in aluminum containers or use pressure-spraying equipment when methyl chloroform is involved.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all equipment used in methyl chloroform manufacturing, use, storage, transfer, and shipping.

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers that emphasize CNS, CVS, liver and skin.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: 1,1,1-Trichloroethane
DOT Hazard Class: ORM-A
ID No.: UN2831
DOT Label: None
DOT Packaging Exceptions: 173.505
DOT Packaging Requirements: 173.605

IMO Shipping Name: 1,1,1-Trichloroethane
IMO Hazard Class: 6.1
ID No.: UN2831
IMO Label: St. Andrews Cross
IMDG Packaging Group: III

MSDS Collection **References:** 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 148, 153, 159, 162, 163, 164

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 312
Trichloroethylene

Issued: 7/79 Revision: F, 9/92

Section 1. Material Identification

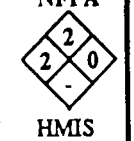
Trichloroethylene (C_2HCl_3) Description: Derived by treating tetrachloroethane with lime or other alkali in the presence of water, or by thermal decomposition of tetrachloroethane followed by steam distillation. Stabilizers such as epichlorohydrin, isobutanol, carbon tetrachloride, chloroform, benzene, or pentanol-2-triethanolamine are then added. Used as a degreasing solvent in electronics and dry cleaning, a chemical intermediate, a refrigerant and heat-exchange liquid, and a diluent in paint and adhesives; in oil, fat, and wax extraction and in aerospace operations (flushing liquid oxygen). Formerly used as a fumigant (food) and anesthetic (replaced due to its hazardous decomposition in closed-circuit apparatus).

Other Designations: CAS No. 79-01-6; acetylene trichloride; Algylen; Anamenth; Benzinol; Cecolene; Chlorylen; Dow-Tri; ethylene trichloride; Germalgene; Narcogen; Triasol; trichloroethene; TCE; 1,1,3-trichloroethylene.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I 2
S 2*
K 3
* Skin absorption

NFPA



HMIS
H 2†
F 2
R 0
PPE‡
† Chronic Effects
‡ Sec. 8

Cautions: TCE is irritating and toxic to the central nervous system (CNS). Inhalation of high concentrations have lead to death due to ventricular fibrillation. Chronic exposure may lead to heart, liver, and kidney damage. The liquid is absorbed through the skin. Although it has a relatively low flash point, TCE burns with difficulty.

Section 2. Ingredients and Occupational Exposure Limits

Trichloroethylene, < 100% [contains stabilizers (Sec. 1)].

1991 OSHA PELs
8-hr TWA: 50 ppm (270 mg/m^3)
15-min STEL: 200 ppm (1080 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
10-hr TWA: 25 ppm (~135 mg/m^3)

1992-93 ACGIH TLVs
TWA: 50 ppm (269 mg/m^3)
STEL: 200 ppm (1070 mg/m^3)

1990 DFG (Germany) MAK
Ceiling: 50 ppm (270 mg/m^3)
Category II: Substances with systemic effects
Half-life: 2 hr to shift length
Peak Exposure Limit: 250 ppm, 30 min average value; 2 peaks/shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 160 ppm/83 min caused hallucinations and distorted perceptions.
Human, lymphocyte: 5 mL/L caused DNA inhibition.
Rabbit, skin: 500 mg/24 hr caused severe irritation.
Rabbit, eye: 20 mg/24 hr caused moderate irritation.
Mouse, oral, TD_{Lo}: 455 mg/kg administered intermittently for 78 weeks produced liver tumors.

* See NIOSH, *RTECS* (KX4550000), for additional irritation, mutation, reproductive, tumorigenic and toxicity data.

Section 3. Physical Data

Boiling Point: 189 °F (87 °C)
Freezing Point: -121 °F (-85 °C)
Viscosity: 0.0055 Poise at 77 °F (25 °C)
Molecular Weight: 131.38
Density: 1.4649 at 20/4 °C
Refraction Index: 1.477 at 68 °F (20 °C/D)
Odor Threshold: 82 to 108 ppm (*not an effective warning*)

Vapor Pressure: 58 mm Hg at 68 °F (20 °C); 100 mm Hg at 32 °F (0 °C)
Saturated Vapor Density (Air = 0.075 lbs/ft^3; 1.2 kg/m^3): 0.0956 lbs/ft^3; 1.53 kg/m^3
Water Solubility: Very slightly soluble; 0.1% at 77 °F (25 °C)
Other Solubilities: Highly soluble in organic solvents (alcohol, acetone, ether, carbon tetrachloride, & chloroform) and lipids.
Surface Tension: 29.3 dyne/cm

Appearance and Odor: Clear, colorless (sometimes dyed blue), mobile liquid with a sweet chloroform odor.

Section 4. Fire and Explosion Data

Flash Point: 90 °F (32 °C) CC | **Autoignition Temperature:** 788 °F (420 °C) | **LEL:** 8% (25 °C); 12.5% (100 °C) | **UEL:** 10% (25 °C); 90% (100 °C)

Extinguishing Media: A Class 1C Flammable Liquid. Although it has a flash point of 90 °F, TCE burns with difficulty. For small fires, use dry chemical, carbon dioxide, water spray, or regular foam. For large fires, use water spray, fog, or regular foam. **Unusual Fire or Explosion Hazards:** Vapor/air mixtures may explode when ignited. Container may explode in heat of fire. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection against TCE. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: TCE slowly decomposes in the presence of light and moisture to form corrosive hydrochloric acid. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include alkalis (sodium hydroxide), chemically active metals (aluminum, beryllium, lithium, magnesium, sodium, potassium, and titanium), epoxides, and oxidants (nitrogen tetraoxide, perchloric acid). Contact with 1-chloro-2,3-epoxy propane or the mono and di 2,3-epoxypropyl ethers of 1,4-butanediol + 2,2-bis-4(2',3'-epoxypropoxy)-phenylpropane can, in the presence of catalytic quantities of halide ions, cause dehydrochlorination of TCE to explosive dichloroacetylene. **Conditions to Avoid:** Exposure to light, moisture, ignition sources, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of TCE (above 300 °C) or exposure to ultraviolet light can produce carbon dioxide (CO_2) and toxic dichloro acetylene (explosive), chlorine, hydrogen chloride, and phosgene gas.

Section 6. Health Hazard Data

Carcinogenicity: The following agencies have rated TCE's carcinogenicity: IARC (Class 3, limited animal evidence & insufficient human data), Germany MAK (Class B, justifiably suspected of having carcinogenic potential), & NIOSH (Class X, carcinogen defined with no further categorization). **Summary of Risks:** TCE vapor is irritating to the eyes, nose, and respiratory tract and inhalation of high concentrations can lead to severe CNS effects such as unconsciousness, ventricular arrythmias, and death due to cardiac arrest. Mild liver dysfunction was also seen at levels high enough to produce CNS effects. Contact with the liquid is irritating to the skin and can lead to dermatitis by defatting the skin. Chronic toxicity is observed in the victims increasing intolerance to alcohol characterized by 'degreasers flush', a transient redness of the face, trunk, and arms. The euphoric effect of TCE has led to craving, and habitual sniffing of its vapors.

Continue on next page

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Section 6. Health Hazard Data, *Continued*

TCE crosses the placental barrier and thus exposes the fetus (any effects are yet unknown). There are increased reports of menstrual disorders in women workers and decreased libido in males at exposures high enough to cause CNS effects. TCE is eliminated unchanged in expired air and as metabolites (trichloroacetic acid & trichloroethanol) in blood and urine. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of the nervous system, skin, heart, liver, and kidney. **Target Organs:** Respiratory, central & peripheral nervous, and cardiovascular (heart) systems, liver, kidney, and skin. **Primary Entry Routes:** Inhalation, skin and eye contact, and ingestion (rarely). **Acute Effects:** Vapor inhalation can cause eye, nose, and throat irritation, nausea, blurred vision, overexcitement, headache, drunkenness, memory loss, irregular heartbeat (resulting in sudden death), unconsciousness, and death due to cardiac failure. Skin contact with the liquid can cause dryness and cracking and prolonged exposure (generally if the victim is unconscious) can cause blistering. Eye contact can cause irritation and watering, with corneal epithelium injury in some cases. Ingestion of the liquid can cause lip, mouth, and gastrointestinal irritation, irregular heartbeat, nausea and vomiting, diarrhea (possibly blood-stained), drowsiness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Effects may persist for several weeks or months after repeated exposure. Symptoms include giddiness, irritability, headache, digestive disturbances, mental confusion, intolerance to alcohol (degreasers flush), altered color perception, loss or impairment of sense of smell, double vision, and peripheral nervous system function impairment including persistent neuritis, temporary loss of sense of touch, and paralysis of the fingers from direct contact with TCE liquid.
FIRST AID Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Do not give milk, as its fat content (TCE is lipid soluble) may inhance gastrointestinal absorption of TCE. **Note to Physicians:** TCE elimination seems to be triphasic with half lives at 20 min, 3 hr, and 30 hr. Some success is seen in treating patients with propranolol, atropine, and disulfiram. Monitor urine and blood (lethal level = 3 to 110 µg/mL) metabolites. BEI = 100 mg/g creatinine (trichloroacetic acid) in urine, *sample at end of workweek.* BEI = 4 mg/L (trichloroethanol) in blood, *sample at end of shift at end of the workweek.* These tests are not 100% accurate indicators of exposure; monitor TCE in expired air as a confirmatory test.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container for later disposal. For large spills, flush to containment area where density stratification will form a bottom TCE layer which can be pumped and containerized. Report any release in excess of 1000 lbs. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Bluegill sunfish, LC_{50} = 44,700 µg/L/96 hr; fathead minnow (*Pimephales promelas*), LC_{50} = 40.7 mg/L/96 hr. **Environmental Degradation:** In air, TCE is photooxidized with a half-life of 5 days and reported to form phosgene, dichloroacetyl chloride, and formyl chloride. In water it evaporates rapidly in minutes to hours. TCE rapidly evaporates and may leach since it does not absorb to sediment. **Soil Absorption/Mobility:** TCE has a Log K_{oc} of 2, indicating high soil mobility. **Disposal:** Waste TCE can be poured on dry sand and allowed to vaporize in isolated location, purified by distillation, or returned to supplier. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) with an acid scrubber to remove halo acids. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a RCRA Hazardous Waste (40 CFR 261.33 & 261.31): No. U228 & F002 (*spent solvent*)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001, CWA Sec. 311 (b)(4), & CWA Sec. 307 (a)]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear chemical safety goggles (cup-type or rubber framed, equipped with impact-resistant glass), per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. At any detectable concentration, wear a SCBA with a full facepiece operated in pressure demand or other positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made from Viton or Neoprene to prevent skin contact. *Do not* use natural rubber or polyvinyl chloride (PVC). **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in steel drums, in a cool, dry, well-ventilated area away from sunlight, heat, ignition sources, and incompatibles (Sec. 5). Store large quantities in galvanized iron, black iron, or steel containers; small amounts in dark (amber) colored glass bottles. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Design processes so that the operator is not directly exposed to the solvent or its vapor. Do not use open electric heaters, high-temperature processes, arc-welding or open flames in TCE atmospheres. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on skin, respiratory, cardiac, central and peripheral nervous systems, and liver and kidney function. Employ air and biological monitoring (BEIs). Instruct employees on safe handling of TCE.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Trichloroethylene
DOT Hazard Class: 6.1
ID No.: UN1710
DOT Packing Group: III
DOT Label: Keep Away From Food
DOT Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60L
b) Cargo Aircraft Only: 220L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MD

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Material Safety Data Sheets Collection:
Sheet No. 313
Perchloroethylene
Issued: 11/78 Revision: E, 9/92

Section 1. Material Identification

Perchloroethylene (C_2Cl_4) Description: By chlorination of hydrocarbons and pyrolysis of the carbon tetrachloride that is formed, or by catalytic oxidation of 1,1,2,2-tetrachloroethane. Used in dry cleaning and textile processing, metal degreasing, insulating fluid and cooling gas in electrical transformers, production of adhesives, aerosols, paints, and coatings; as a chemical intermediate, a solvent for various applications, extractant for pharmaceuticals, a pesticide intermediate, and an antihelminthic (parasitic worm removal) agent in veterinary medicine.
Other Designations: CAS No. 127-18-4, Ankilostin, carbon dichloride, Didakene, ethylene tetrachloride, Perchlor, Perclene, Perk, Tetracap, tetrachloroethylene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

R 1
I 3
S 2*
K 0
* Skin absorption

NFPA
0 / 2 0 / -

HMIS
H 2†
F 0
R 0
PPE‡
† Chronic effects
‡ Sec. 8

Cautions: Perchloroethylene is a central nervous system depressant, causes liver and kidney damage (from acute or chronic exposures), and is considered an IARC Class 2B carcinogen (animal sufficient evidence, human inadequate data).

Section 2. Ingredients and Occupational Exposure Limits

Perchloroethylene, < 99%. Impurities include a small amount of amine or phenolic stabilizers.

1991 OSHA PEL
8-hr TWA: 25 ppm (170 mg/m³)

1990 IDLH Level
500 ppm

1990 NIOSH REL
NIOSH-X Carcinogen
Limit of Quantitation: 0.4 ppm

1992-93 ACGIH TLVs
TWA: 50 ppm (339 mg/m³)
STEL: 200 ppm (1357 mg/m³)

1990 DFG (Germany) MAK
TWA: 50 ppm (345 mg/m³)
Category II: substances with systemic effects
Half-life: < 2 hr
Peak Exposure Limit: 100 ppm, 30 min average value, 4/shift

1985-86 Toxicity Data*
Man, inhalation, TC_{Lo}: 280 ppm/2 hr caused conjunctival irritation and anesthesia.
Human, lung: 100 mg/L caused unscheduled DNA synthesis.
Rat, oral, LD_{50}: 3005 mg/kg; caused somnolence, tremor, and ataxia.
Rat, inhalation, TC_{Lo}: 200 ppm/6 hr given intermittently over 2 years produced leukemia and testicular tumors.
Rabbit, eye: 162 mg caused mild irritation.
Rabbit, skin: 810 mg/24 hr caused severe irritation.

* See NIOSH, *RTECS* (KX3850000), for additional irritation, mutation, reproductive, tumorigenic, & toxicity data.

Section 3. Physical Data

Boiling Point: 250 °F (121.2 °C)
Freezing Point: -8 °F (-23.35 °C)
Vapor Pressure: 13 mm Hg at 68 °F (20 °C)
Surface Tension: 31.74 dyne/cm at 68 °F (20 °C)
Viscosity: 0.84 cP at 77 °F (25 °C)
Refraction Index: 1.50534 at 68 °F (20 °C)
Molecular Weight: 165.82

Density: 1.6311 at 59 °F (15/4 °C)
Water Solubility: 0.02% at 77 °F (25 °C)
Other Solubilities: Miscible with alcohol, ether, benzene, chloroform, and oils.
Odor Threshold: 47 to 71 ppm (poor warning properties since olfactory fatigue is probable)
Evaporation Rate: 0.15 gal/ft²/day at 77 °F (25 °C)
Saturated Vapor Density (Air = 0.075 lb/ft³ or 1.2 kg/m³): 0.081 lb/ft³ or 1.296 kg/m³

Appearance and Odor: Colorless liquid with an ether-like odor.

Section 4. Fire and Explosion Data

Flash Point: Nonflammable	Autoignition Temperature: Nonflammable	LEL: None reported	UEL: None reported

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2). For large fires, use water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: Vapors are heavier than air and collect in low-lying areas.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Perchloroethylene is stable up to 932 °F (500 °C) in the absence of catalysts, moisture, and oxygen but deteriorates rapidly in warm, moist climates. It is slowly decomposed by light. Amine or phenolic stabilizers are usually added. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Slowly (faster in presence of water) corrodes aluminum, iron, and zinc. It is incompatible with chemically active metals (i.e., barium, beryllium, and lithium (explodes with lithium shavings), strong oxidizers, sodium hydroxide, caustic soda, potash, and nitric acid. Perchloroethylene forms an explosive mixture with dinitrogen tetraoxide and reacts with activated charcoal at 392 °F (200 °C) to yield hexachloroethane and hexachlorobenzene. **Conditions to Avoid:** Contact with moisture and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of perchloroethylene can produce carbon dioxide and toxic chlorine, hydrogen chloride, and phosgene gas (also produced by contact with UV light).

Section 6. Health Hazard Data

Carcinogenicity: Perchloroethylene is listed as a carcinogen by The IARC (Group 2B, animal sufficient evidence, human inadequate data),[164] NTP (Class 2, reasonably anticipated as a carcinogen, with limited human evidence and sufficient animal evidence),[169] NIOSH (Class-X, carcinogen defined with no further explanation),[164] and DFG (MAK-B, justifiably suspected of having carcinogenic potential)[164]. There is some controversy regarding human carcinogenicity because even though there is an increased number of cancers of the skin, colon, lung, urogenital tract, and lympho-sarcomas; the dry cleaning workers studied were also exposed to other chemicals. **Summary of Risks:** Perchloroethylene is stored in the fatty tissue and slowly metabolized with the loss of chlorine. The half-life of its urinary metabolite (trichloroacetic acid) is 144 hours. Perchloroethylene exerts the majority of its toxicity on the central nervous system causing symptoms ranging from light-headedness and slight 'inebriation' to unconsciousness. Liver damage is possible after severe acute or minor long-term exposure. It has a synergistic effect with toluene.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Medical Conditions Aggravated by Long-Term Exposure: Nervous, liver, kidney, or skin disorders. **Target Organs:** Liver, kidney, eyes, upper respiratory tract, skin, and central nervous system. **Primary Entry Routes:** Inhalation and skin and eye contact. **Acute Effects:** Exposure to high levels can cause liver damage which may take several weeks to develop. Vapor exposure can cause slight smarting of the eyes and throat (in high concentrations). In human studies, exposure to 2000 ppm/5 min caused mild CNS depression; 600 ppm/10 min caused numbness around the mouth, dizziness, and incoordination; 100 ppm/7 hr caused mild eye, nose, and throat irritation, flushing of the face and neck, headache, somnolence, and slurred speech. Skin contact may produce dermatitis because of perchloroethylene's defatting action (more common after repeated exposure). Direct eye contact causes tearing and burning but no permanent damage. Ingestion is rare but can cause irritation of the lips, mouth and gastrointestinal tract, irregular heartbeat, nausea & vomiting, diarrhea (possibly blood stained), drowsiness, unconsciousness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Prolonged exposure can cause impaired memory, extremity (hands, feet) weakness, peripheral neuropathies, impaired vision, muscle cramps, liver damage (fatty degeneration, necrosis, yellow jaundice, and dark urine) and kidney damage (oliguric uremia, conjestion and granular swelling).

FIRST AID ***Rescuers must not enter areas with potentially high perchloroethylene levels without a self-contained breathing apparatus.***
Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. *Never administer adrenalin!* **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Be sure victim's head is positioned to avoid aspiration of vomitus into the lungs. **Note to Physicians:** Monitor level of consciousness, EEG (abnormalaties may indicate chronic toxicity), blood enzyme levels (for 2 to 3 wk after exposure), EKG, adequacy of respirations & oxygenation, and liver and kidney function. *BEIs:* C_2Cl_4 in expired air (10 ppm), sample prior to last shift of work week; C_2Cl_4 in blood (1 mg/L), sample prior to last shift of work week; trichloroacetic acid in urine (7 mg/L), sample at end of workweek.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources (although noncombustible, it forms toxic vapors from thermal decomposition). For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for later disposal. For large spills, dike far ahead of spill and await reclamation or disposal. Report any release in excess of 1 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to soil, perchloroethylene evaporates and some leaches to groundwater. It may absorb slightly to soils with heavy organic matter. Biodegradation may be important in anaerobic soils. In water, it is subject to rapid volatilization with an estimated half-life from <1 day to several weeks. In air, it exists mainly in the vapor-phase and is subject to photooxidation with a half-life of 30 minutes to 2 months. **Ecotoxicity Values:** Guppy (*Poecilia reticulata*), LC_{50} = 18 ppm/7 days; fathead minnow (*Pimephales promelas*), LC_{50} = 18.4 mg/L/96 hr, flow through bioassay. **Disposal:** Consider recovery by distillation. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) or fluidized bed incineration at 842 to 1796 °F (450 to 980 °C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U210
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per CWA Sec. 307 (a)]
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear a faceshield (8 inch minimum) per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use a supplied-air respirator or SCBA with a full facepiece operated in pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber, Neoprene, or Viton to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from sunlight, and incompatibles. Do not store sludge from vapor degreasers in tightly-sealed containers and keep outside until disposal is arranged. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Check stabilizer levels frequently and ventilation equipment (air velocity, static pressure, air valve) at least every 3 months. Install an air dryer in ventlines to storage tanks to prevent moisture from rusting and weakening the tank and contaminating or discoloring its contents. Purge all tanks before entering for repairs or cleanup. Build a dike around storage tanks capable of containing all the liquid. Ground tanks to prevent static electricity. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize liver, kidney, and nervous system function, and the skin. Alcoholism may be a predisposing factor.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Tetrachloroethylene
DOT Hazard Class: 6.1
ID No.: UN1897
DOT Packing Group: III
DOT Label: Keep away from food
Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 315
Chloroform

Issued: 11/77 Revision: D, 9/92

Section 1. Material Identification

Chloroform ($CHCl_3$) Description: Derived by chlorination of methane, hydrochlorination of methanol, or reaction of chlorinated lime with acetone, acetaldehyde, or ethanol. Purified by extraction with concentrated sulfuric acid and rectification. Used in the manufacture of fluorocarbons (mainly FC-22) for refrigerants, in plastics, photographic processing, fire extinguishers, insecticides, and dry cleaning; as a solvent for fats, oils, waxes, rubbers, alkaloids, Gutta-Percha, and resins. Used as an anesthetic since 1847 but abandoned within the last few decades because of cardiac arrest during surgery and delayed death due to liver injury.

Other Designations: CAS No. 67-66-3, Freon-20, methane trichloride, methenyl chloride, R-20 (refrigerant), trichloroform, trichloromethane, TCM. Improperly called 'formyl chloride.'

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Chloroform is considered one of the most dangerous and volatile chlorinated hydrocarbons. It is a central nervous system (CNS) and cardiac depressant, an eye, skin, and respiratory tract irritant, and causes liver and kidney damage from acute and chronic exposure.

R 1
I 3
S 2*
K 2
* Skin absorption

NFPA

HMIS
H 3†
F 0
R 0
PPE‡
† Chronic effects
‡ Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Chloroform, ca 99%. Usually contains 0.75% ethanol as a stabilizer. Impurities include bromodichloromethane, vinylidene, and diethyl carbonate.

1991 OSHA PEL
8-hr TWA: 2 ppm (9.78 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
60 min STEL: 2 ppm (9.78 mg/m^3)

1992-93 ACGIH TLV
TWA: 10 ppm (49 mg/m^3)

1990 DFG (Germany) MAK
TWA: 10 ppm (50 mg/m^3)
Category II: Substances with systemic effects. Half-life = 2 hr
Peak Exposure Limit: 20 ppm, 30 min average value, 4/shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 10 mg/m^3/1 year caused anorexia, nausea, and vomiting.
Rat, oral, TD_{Lo}: 13832 mg/kg given continuously for 2 years caused leukemia.
Rat, oral, LD_{50}: 908 mg/kg caused weight loss or decreased weight gain.
Rat, inhalation, TC_{Lo}: 30 ppm/7 hr administered from the 6 to 15 day of pregnancy caused fetotoxicity or developmental abnormalities of the musculoskeletal system.
Rabbit, eye: 20 mg/24 hr caused moderate irritation.

* See NIOSH, *RTECS* (FS9100000), for additional irritation, mutation, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 143 °F (62 °C)
Freezing Point: -82 °F (-63.5 °C)
Molecular Weight: 119.39
Viscosity: 5.63 mP at 68 °F (20 °C)
Relative Evaporation Rate (BuAc=1): 11.6
Surface Tension: 27.1 dyne/cm at 68 °F (20 °C)
Refraction Index: 1.4422 at 77 °F (25 °C)
Density: 1.49845 at 59 °F (15 °C)
Water Solubility: Nearly insoluble; 0.5% at 77 °F (25 °C)
Other Solubilities: Soluble in ethanol, ethyl ether, benzene, acetone, carbon disulfide, and carbon tetrachloride.
Odor Threshold: 85 to 307 ppm (*range from combined sources*)
Vapor Pressure: 160 mm Hg at 68 °F (20 °C); 200 mm Hg at 77 °F (25 °C)
Saturated Vapor Density (Air = 0.075 lb/ft³ or 1.2 kg/m³): 0.136 lb/ft^3 or 2.183 kg/m^3

Appearance and Odor: Colorless, volatile liquid with a heavy, ethereal odor.

Section 4. Fire and Explosion Data

Flash Point: Nonflammable	**Autoignition Temperature:** Nonflammble	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Nonflammable from standard tests in air but will burn on prolonged exposure to flame or high temperature. To fight fire, use extinguishing agents suitable for surrounding fire. *Do not* scatter material with a high-pressure water stream. **Unusual Fire or Explosion Hazards:** Container may explode in heat of fire. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is *not* effective. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Chloroform is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. It's pH decreases on prolonged exposure to air and light due to hydrochloric acid (HCl) formation. The recommended shelf-life is 2 months for full containers and 2 weeks for partially full containers. **Chemical Incompatibilities:** Incompatible with acetone, alkalis, aluminum, disilane, lithium, magnesium, dinitrogen dioxide, nitrogen tetroxide, perchloric acid, phosphorus pentoxide, potassium, potassium hydroxide, methyl alcohol, potassium *tert*-butoxide, sodium, sodium hydroxide, sodium methylate, sodium-potassium alloy, triisopropylphosphine, calcium hydroxide, and fluorine and any strong oxidizers. **Conditions to Avoid:** Exposure to light, prolonged heat, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of $CHCl_3$ can produce carbon dioxide and toxic chlorine, HCl, and phosgene gas. $CHCl_3$ decomposes at 437 °F to formic acid, carbon monoxide, and HCl on prolonged heating with water.

Section 6. Health Hazard Data

Carcinogenicity: Chloroform is considered a carcinogen by the IARC (Class-2B, possibly carcinogenic in humans with limited human and sufficient animal evidence),[164] NTP (Class 2, reasonably anticipated to be a carcinogen, limited human and sufficient animal evidence),[169] and NIOSH (Class X, carcinogen defined with no further categorization),[166] DFG (MAK-B, justifiably suspected of having carcinogenic potential),[163] and ACGIH (Class A2, suspected human carcinogen based on limited epidemiologic evidence or demonstration)[163]. Carcinogenicity tends to be organ specific primarily to the liver and kidneys. **Summary of Risks:** Chloroform is a CNS depressant, eye, skin, and respiratory tract irritant, and causes damage to the liver and kidneys. Symptoms range from dizziness to cardiac arrythmias resulting in death. Chloroforms' toxicity is due to its easy lipid solubility. Avoid exposure during pregnancy because $CHCl_3$ diffuses readily across the placenta. Alcoholics seem to be affected sooner and more severely than others from chloroform exposure (alcohol may already have damaged the liver). Ethanol, polybrominated biphenols, steroids, and ketones potentiate chloroform's toxicity.

Continue on next page

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Section 6. Health Hazard Data

Target Organs: Liver, kidney, heart, eyes, skin. **Primary Entry Routes:** Inhalation, ingestion, skin contact/absorption. **Medical Conditions Aggravated by Long-Term Exposure:** Alcoholism, liver, kidney, or nervous system disorders. **Acute Effects:** Vapor inhalation causes varying degrees of CNS depression depending on concentration and exposure length. Symptoms include headache, nausea, dizziness, drunkenness, progressive weakness, vomiting, thirst, delirium, and disorientation. Exposure to 14,000 to 16,000 ppm has caused rapid unconsciousness. Severe acute exposures can damage the liver and kidney (damage is usually not observed for 24 to 48 hr post exposure), respiratory failure, severe cardiac arrythmias (reason for discontinuation of use as an anesthetic), and death. Apparent recovery from heavy exposures may result in delayed death due to liver or kidney failure. Death usually occurs 4 to 5 days post exposure and autopsy shows massive liver necrosis. Vapors cause eye irritation and spasmodic winking. Direct eye contact with the liquid causes immediate burning pain and possible corneal epithelium damage. Skin contact with the liquid produces burning pain, erythema, and vesiculation due to defatting of the skin. Ingestion can cause gastrointestinal irritation, irregular heartbeat, nausea and vomiting, diarrhea (possibly blood-stained), drowsiness, unconsciousness, and state of shock. **Chronic Effects:** Prolonged inhalation of chloroform vapors causes fatigue, digestive disturbances, frequent and burning urination, mental dullness, and CNS and peripheral neuropathies. Liver (fatty degeneration and enlargement with hepatitis seen in dogs) and kidney damage may also occur.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, to dilute. *Do not* induce vomiting because victim may become obtunded. Gastric lavage may be indicated if patient is comatose or at risk of convulsing. **Note to Physicians:** Because effects may be delayed (especially kidney and liver problems), keep victim under observation for 24 to 48 hr. Administration of fluids may help to prevent kidney failure. Obtain blood glucose, urinalysis, liver function tests, chest x-ray, and monitor cardiac function and fluid/electrolyte status. Monitor liver and kidney function for 4 to 5 days after exposure. Disulfiram, its metabolites, and a high carbohydrate diet appear to protect somewhat against chloroform toxicity. *Do not give adrenalin!* Tests may show increased bilirubin, ketosis, lowered blood prothrombin, and fibrogen.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. If possible without risk, move container from spill area. Cleanup personnel should wear fully encapsulating vapor-protective clothing. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for disposal. For large spills, dike far ahead of spill and contain for later disposal or reclamation. Spills in water may need to be trapped at the bottom with sand bag barriers and treated with activated carbon and removed by suction hoses, mechanical lifts, and dredges. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Rainbow Trout (*Salmo airdneri*), LC_{50} = 2030 µg/L; bluegill (*Lepomis macrochirus*), LC_{50} = 100,000 µg/L/96 hr; largemouth bass (*Micropterus salmoides*) LC_{50} = 51 ppm/96 hr. **Environmental Degradation:** If released to land, most chloroform evaporates rapidly (due to high vapor pressure) while some may leach to groundwater where it remains for a long time on the bottom. If released to water, chloroform evaporates rapidly with estimated half-lifes of 6 hr (river), 40 hr (pond), 9 to 10 days (lake). In air, chloroform photodegrades with a half-life of 80 days. It can be transported long distances and some may return to earth via rain. **Disposal:** Reclamation is possible through distillation or steam stripping. Chloroform is a candidate for liquid injection, rotary kiln, or fluidized bed incineration with an acid scrubber. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U044
Listed as a SARA Extremely Hazardous Substance (40 CFR 355), TPQ: 10,000 lb
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 10 lb (4.54 kg) [* per RCRA, Sec. 3001; CWA, Sec. 311(b)(4), & CWA Sec. 307(a)]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear chemical safety goggles for concentrations of 5 ppm to 2% and a full facepiece for levels above 2%, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration use a supplied-air respirator or SCBA with a full facepiece and operated in pressure-demand or other positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of polyvinyl alcohol or Viton (breakthrough times > 1 hr) to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before use. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in lead-lined or mild steel containers of all-welded construction in a cool (< 30 °), dry, well-ventilated area away from direct light and incompatibles. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Isolate operations involving chloroform. **Administrative Controls:** It is suggested that chloroform use for extractions in labs should be avoided and replaced because of its toxicity and carcinogenic potential. Consider preplacement and periodic medical exams of exposed workers.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Chloroform
DOT Hazard Class: 6.1
ID No.: UN1888
DOT Packing Group: II
DOT Label: Poison
Special Provisions (172.102): N36, T14

Packaging Authorizations
a) Exceptions: None
b) Nonbulk Packaging: 173.202
c) Bulk Packaging: 173.243

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

SDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 153, 159, 163, 164, 167, 168, 169, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 316
Benzene

Issued: 11/78 Revision: E, 8/90

Section 1. Material Identification

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Benzene (C_6H_6) Description: Derived by fractional distillation of coal tar, hydrodealkylation of toluene or pyrolysis of gasoline, catalytic reforming of petroleum, and transalkylation of toluene by disproportionation reaction. Used as a fuel; a chemical reagent; a solvent for a large number of materials such as paints, plastics, rubber, inks, oils, and fats; in manufacturing phenol, ethylbenzene (for styrene monomer), nitrobenzene (for aniline), dodecylbenzene (for detergents), cyclohexane (for nylon), chlorobenzene, diphenyl, benzene hexachloride, maleic anhydride, benzene-sulfonic acid, artificial leather, linoleum, oil cloth, varnishes, and lacquers; for printing and lithography; in dry cleaning; in adhesives and coatings; for extraction and rectification; as a degreasing agent; in the tire industry; and in shoe factories. Benzene has been banned as an ingredient in products intended for household use and is no longer used in pesticides.
Other Designations: CAS No. 0071-43-2, benzol, carbon oil, coal naphtha, cyclohexatriene, mineral naphtha, nitration benzene, phene, phenyl hydride, pyrobenzol.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

R 1
I 4
S 2*
K 4
*Skin absorption

NFPA

HMIS
H 3
F 3
R 0
PPG†
† Sec. 8

Cautions: Benzene is a confirmed *human carcinogen* by the IARC. *Chronic low-level exposure may cause cancer (leukemia) and bone marrow damage, with injury to blood-forming tissue.* It is also a dangerous fire hazard when exposed to heat or flame.

Section 2. Ingredients and Occupational Exposure Limits

Benzene, ca 100%*

1989 OSHA PELs
(29 CFR 1910.1000, Table Z-1-A)
8-hr TWA: 1 ppm, 3 mg/m³
15-min STEL: 5 ppm, 15 mg/m³

(29 CFR 1910.1000, Table Z-2)
8-hr TWA: 10 ppm
Acceptable Ceiling Concentration: 25 ppm
Acceptable Maximum Peak: 50 ppm (10 min)†

1989-90 ACGIH
TLV-TWA: 10 ppm, 32 mg/m³

1988 NIOSH RELs
TWA: 0.1 ppm, 0.3 mg/m³
Ceiling: 1 ppm, 3 mg/m³

1985-86 Toxicity Data‡
Man, oral, LD_{Lo}: 50 mg/kg; no toxic effect noted
Man, inhalation, TC_{Lo}: 150 ppm inhaled intermittently over 1 yr in a number of discrete, separate doses affects the blood (other changes) and nutritional and gross metabolism (body temperature increase)
Rabbit, eye: 2 mg administered over 24 hr produces severe irritation

* OSHA 29 CFR 1910.1000, Subpart Z, states that the final benzene standard in 29 CFR 1910.1028 applies to all occupational exposures to benzene except in some subsegments of industry where exposures are consistently under the action level (i.e., distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures); for the excepted subsegments, the benzene limits in Table Z-2 apply.
† Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift.
‡ See NIOSH, *RTECS* (CY1400000), for additional irritative, mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 176 °F (80 °C)
Melting Point: 42 °F (5.5 °C)
Vapor Pressure: 100 mm Hg at 79 °F (26.1 °C)
Vapor Density (Air = 1): 2.7
Evaporation Rate (Ether = 1): 2.8
Molecular Weight: 78.11
Specific Gravity (15 °C/4 °C): 0.8787
Water Solubility: Slightly (0.180 g/100 g of H_2O at 25 °C)
% Volatile by Volume: 100
Viscosity: 0.6468 mPa at 20 °C

Appearance and Odor: A colorless liquid with a characteristic sweet, aromatic odor. The odor recognition threshold (100% of panel) is approximately 5 ppm (unfatigued) in air. Odor *is not* an adequate warning of hazard.

Section 4. Fire and Explosion Data

Flash Point: 12 °F (-11.1 °C), CC	**Autoignition Temperature:** 928 °F (498 °C)	**LEL:** 1.3% v/v	**UEL:** 7.1% v/v

Extinguishing Media: Use dry chemical, foam, or carbon dioxide to extinguish benzene fires. Water may be ineffective as an extinguishing agent since it can scatter and spread the fire. Use water spray to cool fire-exposed containers, flush spills away from exposures, disperse benzene vapor, and protect personnel attempting to stop an unignited benzene leak.
Unusual Fire or Explosion Hazards: Benzene is a Class 1B flammable liquid. A concentration exceeding 3250 ppm is considered a potential fire explosion hazard. Benzene vapor is heavier than air and can collect in low lying areas or travel to an ignition source and flash back. Explosive and flammable benzene vapor-air mixtures can easily form at room temperature. Eliminate all ignition sources where benzene is used, handled, or stored.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Structural firefighter's protective clothing provides limited protection. Stay out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Runoff to sewer can create pollution, fire, and explosion hazard.

Section 5. Reactivity Data

Stability/Polymerization: Benzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Benzene explodes on contact with diborane, permanganic acid, bromine pentafluoride, peroxodisulfuric acid, and peroxomonosulfuric acid. It ignites on contact with dioxygen difluoride, dioxygenyl tetrafluoroborate, iodine heptafluoride, and sodium peroxide + water. Benzene forms sensitive, explosive mixture with iodine pentafluoride, ozone, liquid oxygen, silver perchlorate, nitryl perchlorate, nitric acid, and arsenic pentafluoride + potassium methoxide (explodes above 30 °C). A vigorous or incandescent reaction occurs with bromine trifluoride, uranium hexafluoride, and hydrogen + Raney nickel [above 410 °F (210 °C)]. Benzene is incompatible with oxidizing materials.
Conditions to Avoid: Avoid heat and ignition sources.
Hazardous Products of Decomposition: Thermal oxidative decomposition of benzene can produce toxic gases and vapors such as carbon monoxide.

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Section 6. Health Hazard Data

Carcinogenicity: The ACGIH, OSHA, and IARC list benzene as, respectively, a supected human carcinogen, a cancer hazard, and, based on sufficient human and animal evidence, a human carcinogen (Group 1).
Summary of Risks: Prolonged skin contact or excessive inhalation of benzene vapor may cause headache, weakness, appetite loss, and fatigue. The most important health hazards are cancer (leukemia) and bone marrow damage with injury to blood-forming tissue from chronic low-level exposure. Higher level exposures may irritate the respiratory tract and cause central nervous system (CNS) depression.
Medical Conditions Aggravated by Long-Term Exposure: Exposure may worsen ailments of the heart, lungs, liver, kidneys, blood, and CNS.
Target Organs: Blood, central nervous system, bone marrow, eyes, upper respiratory tract, and skin.
Primary Entry Routes: Inhalation, skin contact.
Acute Effects: Symptoms of acute overexposure include irritation of the eyes, nose, and respiratory tract, breathlessness, euphoria, nausea, drowsiness, headache, dizziness, and intoxication. Severe exposure may lead to convulsions and unconsciousness. Skin contact may cause a drying rash (dermatitis).
Chronic Effects: Long-term chronic exposure may result in many blood disorders ranging from aplastic anemia (an inability to form blood cells) to leukemia.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Immediately rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air. Emergency personnel should protect against inhalation exposure. Provide CPR to support breathing or circulation as necessary. Keep awake and transport to a medical facility.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* since aspiration may be fatal. Call a physician immediately.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Evaluate chronic exposure with a CBC, peripheral smear, and reticulocyte count for signs of myelotoxicity. Follow up any early indicators of leukemia with a bone marrow biopsy. Urinary phenol conjugates may be used for biological monitoring of recent exposure. Acute management is primarily supportive for CNS depression.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a benzene spill control and countermeasure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel, eliminate all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation, eye contact, and skin absorption. Absorb as much benzene as possible with an inert, noncombustible material. For large spills, dike far ahead of spill and contain liquid. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of confined spaces such as sewers, watersheds, and waterways because of explosion danger. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U019
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [* per Clean Water Act, Sec. 307 (a), 311 (b)(4), 112; and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Tables Z-1-A and Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations at least below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from all heat and ignition sources and incompatible materials. *Caution! Benzene vapor may form explosive mixtures in air.* To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. When opening or closing benzene containers, use nonsparking tools. Keep fire extinguishers readily available.
Engineering Controls: Because OSHA specifically regulates benzene (29 CFR 1910.1028), educate workers about its potential hazards and dangers. Minimize all possible exposures to carcinogens. If possible, substitute less toxic solvents for benzene; use this material with extreme caution and only if absolutely essential. Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Designate regulated areas of benzene use (see legend in the box below) and label benzene containers with "DANGER, CONTAINS BENZENE, CANCER HAZARD."
Other Precautions: Provide preplacement and periodic medical examinations with emphasis on a history of blood disease or previous exposure.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Benzene (*benzol*)
DOT Hazard Class: Flammable liquid
ID No.: UN1114
DOT Label: Flammable liquid
DOT Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Benzene
IMO Hazard Class: 3.2
ID No.: UN1114
IMO Label: Flammable liquid
IMDG Packaging Group: II

DANGER
BENZENE
CANCER HAZARD
FLAMMABLE–NO SMOKING
AUTHORIZED PERSONNEL ONLY
RESPIRATOR REQUIRED

MSDS Collection **References:** 1, 2, 12, 26, 73, 84-94, 100, 101, 103, 109, 124, 126, 127, 132, 134, 136, 138, 139, 143
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:
Sheet No. 317
Toluene
Issued: 8/79 Revision: E, 9/92 Errata: 2/94

Section 1. Material Identification

Toluene ($C_6H_5CH_3$) Description: Derived from petroleum i.e., dehydrogenation of cycloparaffin fractions followed by the aromatization of saturated aromatic hydrocarbons or by fractional distillation of coal-tar light oil and purified by rectification. Used widely as a solvent (replacing benzene in many cases) for oils, resins, adhesives, natural rubber, coal tar, asphalt, pitch, acetyl celluloses, cellulose paints and varnishes; a diluent for photogravure inks, raw material for organic synthesis (benzoyl & benzilidene chlorides, saccharine, TNT, toluene diisocyanate, and many dyestuffs), in aviation and high octane automobile gasoline, as a nonclinical thermometer liquid and suspension solution for navigational instruments.

R 1
I 3
S 2*
K 3
* Skin absorption

NFPA

HMIS
H 2- Chronic effects
F 3
R 0
PPE-Sec. 8

Other Designations: CAS No. 108-88-3, Methacide, methylbenzene, methylbenzol, phenylmethane, toluol, Tolu-sol.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Toluene is an eye, skin, and respiratory tract irritant becoming narcotic at high centrations. Liver and kidney damage has occurred. Pregnant women chronically exposed to toluene have shown teratogenic effects. Toluene is highly flammable.

Section 2. Ingredients and Occupational Exposure Limits

Toluene, < 100%; may contain a small amount of benzene (~ 1%), xylene, and nonaromatic hydrocarbons.

1991 OSHA PELs
8-hr TWA: 100 ppm (375 mg/m^3)
15-min STEL: 150 ppm (560 mg/m^3)

1990 IDLH Level
2000 ppm

1990 NIOSH RELs
TWA: 100 ppm (375 mg/m^3)
STEL: 150 ppm (560 mg/m^3)

1992-93 ACGIH TLV (Skin)
TWA: 50 ppm (188 mg/m^3)

1990 DFG (Germany) MAK*
TWA: 100 ppm (380 mg/m^3)
Half-life: 2 hr to end of shift
Category II: Substances with systemic effects
Peak Exposure Limit: 500 ppm, 30 min average value, 2/shift

1985-86 Toxicity Data†
Man, inhalation, TC_{Lo}: 100 ppm caused hallucinations, and changes in motor activity and changes in psychophysiological tests.
Human, oral, LD_{Lo}: 50 mg/kg; toxic effects not yet reviewed
Human, eye: 300 ppm caused irritation.
Rat, oral, LD_{50}: 5000 mg/kg
Rat, liver: 30 µmol/L caused DNA damage.

* Available information suggests damage to the developing fetus is probable.
†See NIOSH, *RTECS* (XS5250000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 232 °F (110.6 °C)
Melting Point: -139 °F (-95 °C)
Molecular Weight: 92.15
Density: 0.866 at 68 °F (20/4 °C)
Surface Tension: 29 dyne/cm at 68 °F (20 °C)
Viscosity: 0.59 cP at 68 °F (20 °C)
Refraction Index: 1.4967 at 20 °C/D

Water Solubility: Very slightly soluble, 0.6 mg/L at 68 °F (20 °C)
Other Solubilities: Soluble in acetone, alcohol, ether, benzene, chloroform, glacial acetic acid, petroleum ether, and carbon disulfide.
Vapor Pressure: 22 mm Hg at 68 °F (20 °C); 36.7 mm Hg at 86 °F (30 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.0797 lb/ft^3 or 1.2755 kg/m^3
Odor Threshold (range of all referenced values): 0.021 to 69 ppm

Appearance and Odor: Colorless liquid with a sickly sweet odor.

Section 4. Fire and Explosion Data

Flash Point: 40 °F (4.4 °C) CC	Autoignition Temperature: 896 °F (480 °C)	LEL: 1.27% v/v	UEL: 7.0% v/v

Extinguishing Media: Toluene is a Class 1B flammable liquid. To fight fire, use dry chemical carbon dioxide, or 'alcohol-resistant' foam. Water spray may be ineffective as toluene floats on water and may actually spread fire. **Unusual Fire or Explosion Hazards:** Concentrated vapors are heavier than air and may travel to an ignition source and flash back. Container may explode in heat of fire. Toluenes' burning rate = 5.7 mm/min and its flame speed = 37 cm/sec. Vapor poses an explosion hazard indoors, outdoors, and in sewers. May accumulate static electricity. Special **Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Apply cooling water to sides of tanks until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from fire and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire because a BLEVE (boiling liquid expanding vapor explosion) may be imminent. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Toluene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can't occur. **Chemical Incompatibilities:** Strong oxidizers, concentrated nitric acid, nitric acid + sulfuric acid, dinitrogen tetroxide, silver perchlorate, bromine trifluoride, tetranitromethane, and 1,3-dichloro-5,5-dimethyl-2,4-imidazolididione. **Conditions to Avoid:** Contact with heat, ignition sources, or incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of toluene can produce carbon dioxide, and acrid, irritating smoke.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list toluene as a carcinogen. **Summary of Risks:** Toluene is irritating to the eyes, nose, and respiratory tract. Inhalation of high concentrations produces a narcotic effect sometimes leading to coma as well as liver and kidney damage. 93% of inhaled toluene is retained in the body of which 80% is metabolized to benzoic acid, then to hippuric acid and excreted in urine. The remainder is metabolized to *o*-cresol and excreted or exhaled unchanged. Toluene metabolism is inhibited by alcohol ingestion and is synergistic with benzene, asphalt fumes, or chlorinated hydrocarbons (i.e. perchloroethylene). Toluene is readily absorbed through the skin at 14 to 23 mg/cm^2/hr. Toluene is absorbed quicker during exercise than at rest and appears to be retained longer in obese versus thin victims; presumably due to its lipid solubility. There is inconsistent data on toluene's ability to damage bone marrow; chronic poisoning has resulted in anemia and leucopenia with biopsy showing bone marrow hypo-plasia. These reports are few and some authorities argue that the effects may have been due to benzene contaminants. Chronic inhalation during pregnancy has been associated with teratogenic effects on the fetus including microcephaly, CNS dysfunction, attentional deficits, developmental delay + language impairment, growth retardation, and physical defects including a small midface, short palpebral fissures, with deep-set eyes, low-set ears, flat nasal bridge with a small nose, micrognathia, and blunt fingertips. There is some evidence that toluene causes an autoimmune illness in which the body produces antibodies that cause inflammation of its own kidney.

Continue on next pag

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Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Alcoholism and CNS, kidney, skin, or liver disease. **Target Organs:** CNS, liver, kidney, skin. **Primary Entry Routes:** Inhalation, skin contact/absorption. **Acute Effects:** Vapor inhalation causes respiratory tract irritation, fatigue, weakness, confusion, dizziness, headache, dilated pupils, watering eyes, nervousness, insomnia, parasthesis, and vertigo progressing to narcotic coma. Death may result from cardiac arrest due to ventricular fibrillation with catecholamines loss. Liquid splashed in the eye causes conjunctival irritation, transient corneal damage and possible burns. Prolonged skin contact leads to drying and fissured dermatitis. Ingestion causes GI tract irritation and symptoms associated with inhalation. **Chronic Effects:** Symptoms include mucous membrane irritation, headache, vertigo, nausea, appetite loss and alcohol intolerance. Repeated heavy exposure may result in encephalopathies (cerebellar ataxia and cognitive dysfunction), liver enlargement, and kidney dystrophy (wasting away). Symptoms usually appear at workdays end, worsen at weeks end and decrease or disappear over the weekend. **FIRST AID Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult an ophthalmologist immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of danger of aspiration into the lungs. Gastric lavage may be indicated if large amounts are swallowed; potential toxicity needs to be weighed against aspiration risk when deciding for or against gastric lavage. **Note to Physicians:** Monitor cardiac function. If indicated, use epinephrine and other catecholamines carefully, because of the possibility of a lowered myocardial threshold to the arrhythmogenic effects of such substances. Obtain CBC, electrolytes, and urinalysis. Monitor arterial blood gases. If toluene has > 0.02% (200 ppm) benzene, evaluate for potential benzene toxicity. BEI: hippuric acid in urine, sample at shift end (2.5 g/g creatinine); Toluene in venous blood, sample at shift end (1.0 mg/L).

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel protect against inhalation and skin/eye contact. Use water spray to cool and disperse vapors but it may not prevent ignition in closed spaces. Cellosolve, hycar absorbent materials, and fluorocarbon water can also be used for vapor suppression/containment. Take up small spill with earth, sand, vermiculite, or other absorbent, noncombustible material. Dike far ahead of large spills for later reclamation or disposal. For water spills, (10 ppm or greater) apply activated carbon at 10X the spilled amount and remove trapped material with suction hoses or use mechanical dredges/lifts to remove immobilized masses of pollutants and precipitates. Toluene can undergo fluidized bed incineration at 842 to 1796 °F (450 to 980 °C), rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C), or liquid injection incineration at 1202 to 2912 °F (650 to 1600 °C). Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Blue gill, LC_{50} = 17 mg/L/24 hr; shrimp (*Crangonfracis coron*), LC_{50} = 4.3 ppm/96 hr; fathead minnow (*Pimephales promelas*), LC_{50} = 36.2 mg/L/96 hr. **Environmental Degradation:** If released to land, toluene evaporates and undergoes microbial degradation. In water, toluene volatilizes and biodegrades with a half-life of days to several weeks. In air, toluene degrades by reaction with photochemically produced hydroxyl radicals. **Disposal:** Treat contaminated water by gravity separation of solids, followed by skimming of surface. Pass through dual media filtration and carbon absorption units (carbon ratio 1 kg to 10 kg soluble material). Return waste water from backwash to gravity separator. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U220
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg)
[* per RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); CWA, Sec. 307 (a)]
Listed as a SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses with shatter-resistant glass and side-shields or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use any chemical cartridge respirator with appropriate organic vapor cartridges, any supplied-air respirator (SAR), or SCBA. For < 2000 ppm, use any SAR operated in continuous-flow mode, any SAR or SCBA with a full facepiece, or any air-purifying respirator with a full facepiece having a chin-style, front or back mounted organic vapor canister. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol with a breakthrough time of > 8 hr, Teflon and Viton are recommended as suitable materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove toluene from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from ignition sources and incompatibles. Outside or detached storage is preferred. If stored inside, use a standard flammable liquids warehouse, room, or cabinet. To prevent static sparks, electrically ground and bond all equipment used with toluene. Do not use open lights in toluene areas. Install Class 1, Group D electrical equipment. Check that toluene is free of or contains < 1% benzene before use. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Adopt controls for confined spaces (29 CFR 1910.146) if entering areas of unknown toluene levels (holes, wells, storage tanks). Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, liver, kidney, and skin. Include hemocytometric and thrombocyte count in cases where benzene is a contaminant of toluene. Monitor air at regular intervals to ensure effective ventilation.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Toluene
DOT Hazard Class: 3
ID No.: UN1294
DOT Packing Group: II
DOT Label: Flammable Liquid
Special Provisions (172.102): T1

Packaging Authorizations
a) Exceptions: 150
b) Non-bulk Packaging: 202
c) Bulk Packaging: 242

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements
Vessel Stowage: B
Other: --

MSDS Collection References: 26, 73, 100, 101, 103, 124, 126, 127, 132, 140, 148, 153, 159, 163, 164, 167, 169, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, CIH, MPH; **Medical Review:** AC Darlington, MD, MPH

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Material Safety Data Sheets Collection:

Sheet No. 318
Xylene *(Mixed Isomers)*

Issued: 11/80 Revision: E, 9/92 Errata: 12/94

Section 1. Material Identification

Xylene (Mixed Isomers) (C_8H_{10}) **Description:** The commercial product is a blend of the three isomers [*ortho*-(*o*-), *meta*-(*m*-), *para*-(*p*-)] with the largest proportion being *m*- xylene. Xylene is obtained from coal tar, toluene by transalkylation, and pseudocumene. Used in the manufacture of dyes, resins, paints, varnishes, and other organics; as a general solvent for adhesives, a cleaning agent in microscope technique; as a solvent for Canada balsam microscopy; as a fuel component; in aviation gasoline, protective coatings, sterilizing catgut, hydrogen peroxide, perfumes, insect repellants, pharmaceuticals, and the leather industry; in the production of phthalic anhydride, isophthalic, and terephthalic acids and their dimethyl esters which are used in the manufacture of polyester fibers; and as an indirect food additive as a component of adhesives. Around the home, xylene is found as vehicles in paints, paint removers, degreasing cleaners, lacquers, glues and cements and as solvent/vehicles for pesticides.

Other Designations: CAS No. 1330-20-7 [95-47-6; 108-38-3; 106-42-3 (*o*-, *m*-, *p*-isomers)], dimethylbenzene, methyltoluene, NCI-C55232, Violet 3, xylol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

R 1
I 2
S 2
K 3

NFPA
3
2 0
–

HMIS
H 2‡
F 3
R 0
PPE ‡
‡ Chronic Effects
‡ Sec. 8

Cautions: Xylene is an eye, skin, and mucous membrane irritant and may be narcotic in high concentrations. It is a dangerous fire hazard.

Section 2. Ingredients and Occupational Exposure Limits

Xylene (mixed isomers): the commercial product generally contains ~ 40% *m*-xylene; 20% each of *o*-xylene, *p*-xylene, and ethylbenzene; and small quantities of toluene. Unpurified xylene may contain pseudocumene.

1991 OSHA PELs
8-hr TWA: 100 ppm (435 mg/m^3)
15-min STEL: 150 ppm (655 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH RELs
TWA: 100 ppm (435 mg/m^3)
STEL: 150 ppm (655 mg/m^3)

1992-93 ACGIH TLVs
TWA: 100 ppm (434 mg/m^3)
STEL: 150 ppm (651 mg/m^3)
BEI (Biological Exposure Index): Methylhippuric acids in urine at end of shift: 1.5 g/g creatinine

1990 DFG (Germany) MAK
TWA: 100 ppm (440 mg/m^3)
Category II: Substances with systemic effects
Half-life: < 2 hr
Peak Exposure: 200 ppm, 30 min, average value, 4 peaks per shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 200 ppm produced olfaction effects, conjunctiva irritation, and other changes involving the lungs, thorax, or respiration.
Man, inhalation, LC_{Lo}: 10000 ppm/6 hr; toxic effects not yet reviewed.
Human, oral, LD_{Lo}: 50 mg/kg; no toxic effect noted.
Rat, oral, LD_{50}: 4300 mg/kg; toxic effect not yet reviewed.
Rat, inhalation, LC_{50}: 5000 ppm/4 hr; toxic effects not yet reviewed.

* See NIOSH, *RTECS* (XE2100000), for additional toxicity data.

Section 3. Physical Data

Boiling Point Range: 279 to 284 °F (137 to 140 °C)*
Boiling Point: *ortho:* 291 °F (144 °C); *meta:* 281.8 °F (138.8 °C); *para:* 281.3 °F (138.5 °C)
Freezing Point/Melting Point: *ortho:* -13 °F (-25 °C); *meta:* -53.3 °F (- 47.4 °C); *para:* 55 to 57 °F (13 to 14 °C)
Vapor Pressure: 6.72 mm Hg at 70 °F (21 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3): 1.23 kg/m^3, 0.077 lbs/ft^3
Appearance and Odor: Clear, sweet-smelling liquid.

Molecular Weight: 106.16
Specific Gravity: 0.864 at 20 °C/4 °C
Water Solubility: Practically insoluble
Other Solubilities: Miscible with absolute alcohol, ether, and many other organic liquids.
Octanol/Water Partition Coefficient: logKow = 3.12-3.20
Odor Threshold: 1 ppm
Viscosity: <32.6 SUS

* Materials with wider and narrower boiling ranges are commercially available.

Section 4. Fire and Explosion Data

Flash Point: 63 to 77 °F (17 to 25 °C) CC	**Autoignition Temperature:** 982 °F (527 °C) (*m*-)	**LEL:** 1.1 (*m*-, *p*-); 0.9 (*o*-)	**UEL:** 7.0 (*m*-, *p*-); 6.7 (*o*-)

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2), water spray or regular foam. For large fires, use water spray, fog or regular foam. Water may be ineffective. Use water spray to cool fire-exposed containers. **Unusual Fire or Explosion Hazards:** Xylene vapors or liquid (which floats on water) may travel to an ignition source and flash back. The heat of fire may cause containers to explode and/or produce irritating or poisonous decomposition products. Xylene may present a vapor explosion hazard indoors, outdoors, or in sewers. Accumulated static electricity may occur from vapor or liquid flow sufficient to cause ignition. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing will provide limited protection. If feasible and without risk, move containers from fire area. Otherwise, cool fire-exposed containers until well after fire is extinguished. Stay clear of tank ends. Use unmanned hose holder or monitor nozzles for massive cargo fires. If impossible, withdraw from area and let fire burn. Withdraw immediately in case of any tank discoloration or rising sound from venting safety device. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Xylene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Xylene is easily chlorinated, sulfonated, or nitrated. **Chemical Incompatibilities:** Incompatibilities include strong acids and oxidizers and 1,3-dichloro-5,5-dimethyl-2,4-imidazolidindione (dichlorohydrantoin). Xylene attacks some forms of plastics, rubber, and coatings. **Conditions to Avoid:** Avoid heat and ignition sources and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of xylene can produce carbon dioxide, carbon monoxide, and various hydrocarbon products.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[169] and OSHA[164] do not list xylene as a carcinogen. **Summary of Risks**: Xylene is an eye, mucous membrane, and respiratory tract irritant. Irritation starts at 200 ppm; severe breathing difficulties which may be delayed in onset can occur at high concentrations. It is a central nervous system (CNS) depressant and at high concentrations can cause coma. Kidney and liver damage can occur with xylene exposure. With prolonged or repeated cutaneous exposure, xylene produces a defatting dermatitis. Chronic toxicity is not well defined, but it is less toxic than benzene. Prior to the 1950s, benzene was often found as a contaminant of xylene and the effects attributed to xylene such as blood dyscrasias are questionable. Since the late 1950s, xylenes have been virtually benzene-free and blood dyscrasias have not been associated with xylenes. Chronic exposure to high concentrations of xylene in animal studies have demonstrated mild reversible decrease in red and white cell counts as well as increases in platelet counts.

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Section 6. Health Hazard Data, *continued*

Menstrual irregularity was reported in association with workplace exposure to xylene perhaps due to effects on liver metabolism. Xylene crosses the human placenta, but does not appear to be teratogenic under conditions tested to date. **Medical Conditions Aggravated by Long-Term Exposure:** CNS, respiratory, eye, skin, gastrointestinal (GI), liver and kidney disorders. **Target Organs:** CNS, eyes, GI tract, liver, kidneys, and skin. **Primary Entry Routes:** Inhalation, skin absorption (slight), eye contact, ingestion. **Acute Effects:** Inhalation of high xylene concentrations may cause dizziness; nausea, vomiting, and abdominal pain; eye, nose, and throat irritation; respiratory tract irritation leading to pulmonary edema (fluid in lung); drowsiness; and unconsciousness. Direct eye contact can result in conjunctivitis and corneal burns. Ingestion may cause a burning sensation in the oropharynx and stomach and transient CNS depression. **Chronic Effects:** Repeated or prolonged skin contact may cause drying and defatting of the skin leading to dermatitis. Repeated eye exposure to high vapor concentrations may cause reversible eye damage, peripheral and central neuropathy, and liver damage. Other symptoms of chronic exposure include headache, fatigue, irritability, chronic bronchitis, and GI disturbances such as nausea, loss of appetite, and gas.

FIRST AID *Emergency personnel should protect against exposure.* **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Carefully dispose of contaminated clothing as it may pose a fire hazard. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. Monitor exposed person for respiratory distress. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, *do not induce vomiting!* If spontaneous vomiting should occur, keep exposed person's head below the hips to prevent aspiration (breathing liquid xylene into the lungs). *Aspiration of a few millimeters of xylene can cause chemical pneumonitis, pulmonary edema, and hemorrhage.* **Note to Physicians:** Hippuric acid or the ether glucuronide of *ortho*-toluic acid may be useful in diagnosis of *meta*-, *para*- and *ortho*-xylene exposure, respectively. Consider gastric lavage if a large quantity of xylene was ingested. Proceed gastric lavage with protection of the airway from aspiration; consider endotracheal intubation with inflated cuff.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and ventilate spill area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. If feasible and without undue risk, stop leak. Use appropriate foam to blanket release and suppress vapors. Water spray may reduce vapor, but does not prevent ignition in closed spaces. For small spills, absorb on paper and evaporate in appropriate exhaust hood or absorb with sand or some non-combustible absorbent and place in containers for later disposal. For large spills dike far ahead of liquid to contain. Do not allow xylene to enter a confined space such as sewers or drains. On land, dike to contain or divert to impermeable holding area. Apply water spray to control flammable vapor and remove material with pumps or vacuum equipment. On water, contain material with natural barriers, booms, or weirs; apply universal gelling agent; and use suction hoses to remove spilled material. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** Little bioconcentration is expected. Biological oxygen demand 5 (after 5 days at 20 °C): 0.64 (no stated isomer). **Ecotoxicity values:** LD_{50}, Goldfish, 13 mg/L/24 hr, conditions of bioassay not specified, no specific isomer. **Environmental Degradation:** In the atmosphere, xylenes degrade by reacting with photochemically produced hydroxyl radicals with a half-life ranging from 1-1.7 hr. in the summer to 10-18 hr in winter or a typical loss of 67-86% per day. Xylenes are resistant to hydrolysis. **Soil Absorption/Mobility:** Xylenes have low to moderate adsorption to soil and when spilled on land, will volatilize and leach into groundwater. **Disposal:** As a hydrocarbon, xylene is a good candidate for controlled incineration. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U239, F003 (spent solvent)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per Clean Water Act, Sec. 311(b)(4); per RCRA, Sec. 3001]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For concentrations >1000 ppm, use any chemical cartridge respirator with organic vapor cartridges; any powered, air-purifying respirator with organic vapor cartridges; any supplied-air respirator; or any self-contained breathing apparatus. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. With breakthrough times > 8 hr, consider polyvinyl alcohol and fluorocarbon rubber (Viton) as materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in clearly labelled, tightly closed, containers in a cool, well-ventilated place, away from strong oxidizing materials and heat and ignition sources. During transferring operations, electrically ground and bond metal containers. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Use hermetically sealed equipment, transfer xylene in enclosed systems, avoid processes associated with open evaporating surfaces, and provide sources of gas release with enclosures and local exhaust ventilation. Use Class I, Group D electrical equipment. **Administrative Controls:** Establish air and biological monitoring programs and evaluate regularly. Consider preplacement and periodic medical examinations including a complete blood count, a routine urinalysis, and liver function tests. Consider hematologic studies if there is any significant contamination of the solvent with benzene. If feasible, consider the replacement of xylene by less toxic solvents such as petrol (motor fuel) or white spirit. Before carrying out maintenance and repair work, steam and flush all equipment to remove any xylene residues.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Xylenes
DOT Hazard Class: 3
ID No.: UN1307
DOT Packing Group: II
DOT Label: Flammable Liquid
Special Provisions (172.102): T1

Packaging Authorizations
a) Exceptions: 173.150
b) Nonbulk Packaging: 173.202
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 5L
b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: –

MSDS Collection **References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 171, 174, 176, 180.
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 320
2-Butoxyethanol

Issued: 11/77 Revision: D, 4/90

Section 1. Material Identification

2-Butoxyethanol Description: Prepared from butyl alcohol and ethylene carbonate or 2-chloroethanol. Also prepared from ethylene glycol and butyl bromide. Used as a solvent for nitrocellulose resins, protective coatings and metal cleaners, grease, albumin, oil, varnishes, enamels, spray lacquers, dry-cleaning compounds, mineral oils, varnish removers, liquid household cleaners; and in hydraulic fluids.

Other Designations: CAS No. 0111-76-2; $C_6H_{14}O_2$; butyl cellosolve; ethylene glycol butyl ether; ethylene glycol monobutyl ether.

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

R 1
I 3
S 2*
K 2
*Skin absorption

NFPA

HMIS
H 2
F 2
R 0
PPG†
† Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

2-Butoxyethanol, ca 100%

OSHA PEL
8-hr TWA: 25 ppm, 120 mg/m³

ACGIH TLV, 1989-90
TLV-TWA: 25 ppm, 120 mg/m³

NIOSH REL, 1987
50 ppm, 240 mg/m³

Toxicity Data*
Rabbit, skin: 500 mg (open Draize test) produces mild irritation
Rat, inhalation, LC_{50}: 450 ppm inhaled for 4 hr produces behavioral (change in motor activity), and kidney, ureter, and bladder (hematuria, blood in the urine) effects
Human, inhalation, TC_{Lo}: 195-ppm exposure for 8 hr produces gastrointestinal effects (nausea or vomiting)

* See NIOSH, *RTECS* (KJ8575000), for additional irritative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 335.1 °F/168.4 °C to 338.4 °F/170.2 °C
Melting Point: < - 40 °F/< - 40 °C
Vapor Pressure: 0.76 mm Hg at 68 °F/20 °C*
Vapor Density (Air = 1): 4.07

Molecular Weight: 118.20 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 0.9012 at 68 °F/20 °C
Water Solubility: Soluble

Appearance and Odor: A clear, mobile liquid with a pleasant odor.

* Low vapor pressure at room temperature contributes substantially to the overall hazard, especially exposure through skin absorption (Sec. 6).

Section 4. Fire and Explosion Data

Flash Point: 143 °F/62 °C	Autoignition Temperature: 460 °F/238 °C	LEL: 1.1% v/v at 200 °F/93 °C	UEL: 12.7% v/v at 275 °F/135 °C

Extinguishing Media: To fight fires, use alcohol foam, dry chemical, CO_2, or water spray. Do not use a solid stream of water since the stream scatters and spreads the fire. Use water spray to cool fire-exposed tanks/containers.

Unusual Fire or Explosion Hazards: 2-Butoxyethanol is a moderate fire hazard when exposed to heat, flame, or strong oxidizers. Vapors are heavier than air and may travel a considerable distance and flashback from an ignition source.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective clothing. This material may be poisonous if inhaled or absorbed through the skin. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: 2-Butoxyethanol is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. 2-Butoxyethanol is moderately volatile.

Chemical Incompatibilities: This material is incompatible with oxidizing materials, heat, and flame. 2-Butoxyethanol may attack metallic aluminum at high temperatures.

Conditions to Avoid: This material attacks some forms of plastics, rubber, and coatings. Autooxidation may produce peroxides.

Hazardous Products of Decomposition: Thermal oxidative decomposition of 2-butoxyethanol can produce toxic vapors and gases, including carbon monoxide.

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists 2-butoxyethanol as a carcinogen. Experimental studies show this material has teratogenic and reproductive effects in laboratory animals. This material has an IDLH (*I*mmediately *d*angerous to *l*ife and *h*ealth) level of 700 ppm.
Summary of Risks: 2-Butoxyethanol is irritating to the skin, eyes, nose, mucous membranes, and throat. Human systemic effects by inhalation include nausea or vomiting, headache, nose tumors, and unspecified eye effects. This material readily penetrates the skin. Toxic action from excessive skin exposure may be more likely than from vapor inhalation. The symptoms of toxic skin absorption and inhalation are similar. Although humans appear less susceptible than animals to 2-butoxyethanol exposure, severe exposure may cause hemolytic anemia (excessive destruction of red blood cells) and hemoglobin in the urine. Prolonged vapor exposure may also damage the liver, kidney, and lungs.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Liver, kidneys, lymphoid system, skin, eyes, blood, respiratory system, central nervous system.
Primary Entry Routes: Inhalation, skin absorption.
Acute Effects: Exposure of 2-butoxyethanol vapors causes conjunctivitis, headache, and upper respiratory tract irritation. Liquid contact with this material causes skin irritation and possible systemic effects, include nausea or vomiting, headache, and hemolytic anemia. Central nervous system depression may result.
Chronic Effects: None reported.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce vomiting with Ipecac syrup.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Systemic acidosis may develop after ingestion.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of spill or leak, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and skin and eye contact. Absorb small quantities with paper towels. Place paper towels in a clean fume hood to completely evaporate. Burn the waste paper in a safe location away from all combustibles. Larger quantities can be absorbed with a noncombustible, inert ingredient and placed in closed disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below OSHA PEL, ACGIH TLV, and NIOSH REL (Sec. 2) . Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated, area away from all oxidizers, heat, sparks, or open flame. Protect containers from physical damage. Do not store 2-butoxyethanol in aluminum containers. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving or transferring operations in production and storage areas. Use nonsparking tools.
Engineering Controls: Avoid vapor inhalation and skin or eye contact with the liquid. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program with training, maintenance, inspection, and evaluation. Use caution when handling this compound since it is readily absorbed through the skin to produce toxic effects. Practice good personal hygiene and housekeeping procedures. Employees working with 2-butoxyethanol should be given preplacement and periodic medical exams which evaluate the kidneys, liver, lungs, skin, and blood. Prevent exposing individuals with kidney disease or hematologic disorders.
Transportation Data:
DOT ID No.: 2369*
* Although not listed in 49 CFR 172.101, .102, 2-butoxyethanol is listed in *DOT Emergency Response Guidebook*.[83]

***MSDS Collection* References:** 1-4, 6-9, 12, 21, 23, 26, 38, 47, 59, 73, 79, 84, 85, 88, 89, 100, 101, 103, 124, 126, 127, 134, 136, 137
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 323
Ethylene Glycol

Issued: 11/80 Revision: D, 9/92

Section 1. Material Identification

Ethylene Glycol (CH_2OHCH_2OH) Description: Derived by hydrolysis of ethylene oxide or oxidation of ethylene in the presence of acetic acid ethylene diacetate with further hydrolysis to the glycol (acetic acid is recycled in the process). Used in antifreeze, hydraulic brake fluids, heat-transfer fluid; in printer, stamp pad, and ball-point pen inks; as a chemical intermediate in production of ethylene glycol esters, ethers, and resinous products (polyester fibers & resins), stabilizer in latex paints, deicer for planes and runways, solvent, softening agent for cellophane, substitute for glycerine in many applications, dehydrating agent for natural gas, metal cleaning agent, and an industrial humectant (promotes moisture retention).
Other Designations: CAS No. 107-21-1; 1,2- dihydroxy ethane; 1,2-ethanediol; ethylene alcohol; ethylene dihydrate; glycol; glycol alcohol; Lutrol-9; Macrogol 400 BPC; Norkool; Tescol; Ucar 17.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Ethylene glycol vapor poses little harm due to its low vapor pressure but when heated or misted in an aerosol, inhalation with subsequent toxicity will occur. Ingestion can cause serious problems ranging from central nervous system (CNS) depression to kidney failure. The liquid is absorbed through the skin but generally in insufficient amounts to cause toxicity. It is combustible.

R 1
I -
S 2*
K 1
* Skin absorption

NFPA

HMIS
H 1†
F 1
R 0
PPE‡
† Chronic effects
‡ Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Ethylene Glycol, ca 100%

1991 OSHA PEL
Ceiling: 50 ppm (125 mg/m³)

1992-93 ACGIH TLV
Ceiling: 50 ppm (127 mg/m³)

1990 NIOSH REL
None established

1990 DFG (Germany) MAK
None established

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 10,000 mg/m³ caused watering eyes and cough.
Human, lymphocyte: 320 mmol/L caused DNA inhibition.
Rabbit, skin: 555 mg (open patch test) caused mild irritation.
Rat, oral, LD_{50}: 4700 mg/kg; no toxic effect noted
Rat, oral, TD_{Lo}: 50 g/kg (6 to 15th day of pregnancy) caused specific developmental abnormalities of the skin, blood, lymph, and musculoskeletal system.

* See NIOSH, *RTECS* (KW2975000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 387 °F (197.5 °C)
Freezing Point: 8.6 °F (-13 °C); *ethylene glycol/water mixture (10.15%) = -3.5 °C, (58.37%) = -48 °C*
Vapor Pressure: 0.05 mm Hg at 68 °F (20 °C)
Saturated Vapor Density (Air = 1.2 kg/m³): ~ same as air
Surface Tension: 48 dyne/cm at 68 °F (20 °C)
Refraction Index: 1.432 at 77 °F (25 °C)
Molecular Weight: 62.08

Density: 1.113 at 25/25 °C; *ethylene glycol/water mixture (10.15%) = 1.013, (50.18%) = 1.067*
Water Solubility: Soluble
Other Solubilities: Miscible with acetic acid, acetone, glycerol, pyridine, lower aliphatic alcohols, aldehydes, and ketones; slightly soluble in ether; practically insoluble in benzene and hydrocarbons.
Viscosity: 26 cP at 59 °F (15 °C), 21 cP at 68 °F (20 °C), 17.3 cP at 77 °F (25 °C)

Appearance and Odor: Colorless, thick, hygroscopic (absorbs water easily), bitter-sweet tasting liquid.

Section 4. Fire and Explosion Data

Flash Point: 232 °F (111 °C) CC	Autoignition Temperature: 748 °F (398 °C)	LEL: 3.2% v/v	UEL: None reported

Extinguishing Media: Fight fire with dry chemical, water spray, carbon dioxide (CO_2), or 'alcohol-resistent' foam. Be aware that water or foam may cause frothing. **Unusual Fire or Explosion Hazards:** Burning Rate = 1 mm/min. Ethylene glycol that is heated or misted in air moderate fire & explosion hazard. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection. Apply cooling water to sides of containers until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Ethylene glycol is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. It is very hygroscopic and absorbs twice its weight in water at 100% relative humidity.
Chemical Incompatibilities: Include chlorosulfonic acid, sulfuric acid, oleum, sodium hydroxide, phosphorus pentasulfide, silvered-copper wire (caused ignition), dimethyl terephthalate, titanium butoxide, causes ignition at room temperature with chromium trioxide, potassium permanganate, and sodium peroxide; causes ignition at 212 °F (100 °C) with ammonium dichromate, silver chlorate, sodium chloride, and uranyl nitrate.
Conditions to Avoid: Exposure to heat, ignition sources, water (absorbs readily), and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of ethylene glycol can produce carbon dioxide (CO_2), acrid smoke, and irritating vapors.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[169] and OSHA[164] do not list ethylene glycol as a carcinogen.
Summary of Risks: Ethylene glycol vapor poses little hazard due to its low vapor pressure, but when heated or misted (in aerosol) it presents a significant health hazard. Some irritation, cough, and headache may occur from repeated exposure to vapors. Ingestion is rare in industrial situations but if it occurs; CNS, cardiovascular, and kidney effects are observed. Symptoms range from a slight 'inebriation' to eventual kidney failure and death. Skin absorption occurs, although toxic amounts have not been reached in any human cases. Animal data is erratic, difficult to quantitate and thus makes it impossible to estimate toxic absorption levels in humans. **Medical Conditions Aggravated by Long-Term Exposure:** CNS, cardiovascular, or kidney disorders. **Target Organs:** CNS, kidney, cardiovascular system, eyes. **Primary Entry Routes:** Inhalation, ingestion, skin and eye contact.

Continue on next page

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Section 6. Health Hazard Data

Acute Effects: Vapor inhalation is generally not a problem unless heated or misted but exposure to vapors over an extended time period has caused throat irritation and headache (volunteers exposed to 12 ppm, 20 to 22 hr/day/4 wk), more pronounced irritation (56 ppm), and intolerable cough and irritation (80 ppm). When heated or misted, ethylene glycol has produced nystagmus (rapid, involuntary, eye movement) and coma. Ingestion can cause serious problems and effects are in three stages. The 1st begins ~ 12 hr post-ingestion and is predominated by CNS effects. Symptoms include nystagmus, some or complete paralysis of eye muscles, swelling and protrusion of the eyes blindspot, depressed reflexes, and convulsions. Stage two affects cardiovascular/pulmonary system with mild hypertension, rapid heart beat, increased respiration, and widespread capillary damage. If patient survives first two stages, kidney complications resulting in necrosis and renal failure occur 24 to 72 hr post-ingestion. Other effects include metabolic acidosis and meningoencephalitis (inflammation of the brain and meninges). The minimum human lethal oral dose is 100 mL.
Chronic Effects: Repeated small exposures by any route can cause severe kidney problems.
FIRST AID
Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water and induce vomiting. **Note to Physicians:** Give sodium bicarbonate intravenously to treat acidosis. Urinalysis may show low specific gravity, proteinuria, pyuria, cylindruria, hematuria, calcium oxide, and hippuric acid crystals. Ethanol can be used in antedotal treatment but monitor blood glucose when administering ethanol because it can cause hypoglycemia. Consider infusion of a diuretic such as mannitol to help prevent or control brain edema and hemodialysis to remove ethylene glycol from circulation.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, remove heat and ignition sources, deny entry, and stay upwind. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container. For large spills, dike far ahead to contain for later reclamation or disposal. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Goldfish (*Carassius auratus*), LD_{50} = > 5000 mg/L/24 hr; guppies (*Poecilia reticulata*), LC_{50} = 493,000 ppm/7 days; rainbow trout, LC_{50} = 18,500/L/96 hr. **Environmental Degradation:** In water, ethylene glycol completely biodegrades in typical river water in 3 days (20°C) and 7 days (8 °C). On land, it leaches into the soil and rapidly biodegrades. In air, ethylene glycol exists in the vapor-phase and reacts with hydroxyl radicals with a half-life of 2 days. **Disposal:** Spray waste into an incinerator or burn in paper packaging. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Other: Wear chemically protective gloves, boots, aprons, and gauntlets made of natural or nitrile rubber or Neoprene to prevent skin contact.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles (Sec. 5).
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all equipment used for and around ethylene glycol.
Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the CNS, cardiopulmonary system, and the kidneys. If ethylene glycol is to be heated or mechanically agitated, exposed workers should protect against vapor inhalation.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Combustible liquid, n.o.s.
DOT Hazard Class: Combustible liquid
ID No.: NA1993
DOT Packing Group: III
DOT Label: None
Special Provisions (172.102): T1

Packaging Group
a) Exceptions: 173.150
b) Nonbulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: --

MSDS Collection **References:** 73, 100, 101, 103, 124, 126, 127, 132, 133, 140, 159, 162, 163, 164, 167, 168, 174, 176
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MD

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Material Safety Data Sheets Collection:

Sheet No. 73
Zinc Metal/Powder

Issued: 7/80 Revision: A, 11/89

Section 1. Material Identification

30

Zinc Metal/Powder Description: A metallic element extracted from ores which are first roasted to form zinc oxide and then: 1) the zinc oxide is leached from the roasted material with sulfuric acid to form a zinc sulfate solution which is electrolyzed in cells to deposit zinc on cathodes and 2) the zinc oxide is reduced with carbon in retorts (distilling vessels) to yield distilled and condensed zinc. Used as ingredient in alloys such as brass, bronze, and die-casting alloys; galvanizing sheet iron; for electrical apparatus, especially castings, building materials, dry cell batteries, automotive equipment, household utensils, railroad car linings; as a fungicide; in nutrition (essential growth element); as reagent in analytical chemistry; in bleaching bone glue, manufacturing sodium hydrosulfite, and insulin zinc salts.
Other Designations: Blue powder; spelter; granular zinc; jasad; merrillite; pasco; Zn; CAS No. 7440-66-6.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

R 1
I 1
S 1
K 1

NFPA
1
0 1
-

HMIS
H 0
F 1
R 1
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Zinc metal/powder, ca 99%

OSHA PEL	ACGIH TLV, 1989-90	NIOSH REL, 1987	Toxicity Data†
None established*	None established*	None established*	Human, inhalation, TC_{Lo}: 124 mg/m³/50 min, pulmonary system effects

* The current OSHA standard and ACGIH (1989-1990) TWA for zinc oxide (ZnO) fumes is 5 mg/m³. The ACGIH TWA for zinc oxide dust is 10 mg/m³, providing that total contains no asbestos and is <1% crystalline silica. NIOSH has recommended a 10-hr TWA of 5 mg/m³ and a ceiling level of 15 mg/m³ (15-min sample) for zinc oxide fume. The TLV-TWA level was set to prevent metal fume fever.
† See NIOSH, *RTECS* (ZG8600000), for additional data with references to irritative effects.

Section 3. Physical Data

Boiling Point: 907 °F (1663 °C)
Melting Point: 419 °F (787 °C)
Vapor Pressure: 1 mm Hg at 909 °F (487 °C)
Brinell Hardness: 31
Atomic Weight: 65.37 g/mol
Specific Gravity (H_2O = 1 at 39 °F (4 °C)): 7.13 at 77 °F (25 °C)
Water Solubility: Insoluble
Index of Explosibility, Zn Powder (<0.1 weak, >10 severe): 0.1

Appearance and Odor: Bluish-white lustrous metal, also finely divided forms.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: Cloud, 1256 °F (680 °C);* dust layer, 860 °F (460°C);* powder, 650 mJ*	LEL: Dust cloud explosion, 0.5 oz/ft³	UEL: None reported

Extinguishing Media: Use special dry chemical or clean dry sand. *Never* use CO_2. Using a direct stream of water may scatter the fire or disperse dust, creating a potentially explosive mixture if exposed to heat or ignition sources. A water spray may be used to cool fire-exposed containers and disperse vapors.
Unusual Fire or Explosion Hazards: Flammable hydrogen gas is liberated by reaction with alkali hydroxides (sodium, potassium, and calcium hydroxides), acids, or even water (when material is in dust form) and is an explosion hazard in a confined space. In a fire, zinc may melt, vaporize, and burn to form ZnO fumes (Sec. 2).
Special Fire-fighting Procedures: For major fires, or if large quantities of this material are involved, fire fighters should wear appropriate protective clothing and respiratory protection. Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

* Zinc dust refers to the product of zinc vapor condensation, and zinc powder to the product of molten zinc atomization (*Zinc Dust and Zinc Powder: Their Production, Properties, and Applications*, B.C. Hafford, W.E. Pepper, and T.B. Lloyd, 1982). Dust 100% thru 74-µm sieve; a 0.96-J spark can ignite a cloud. The ignition temperature in CO_2 is 896 °F (480 °C). The reaction temperature in a nitrogen atmosphere is 1112 °F (600 °C).

Section 5. Reactivity Data

Stability/Polymerization: Zinc is stable in dry air at room temperature. Moist zinc dust can react exothermically and ignite spontaneously in air. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Zinc dust is an explosion hazard when reacted with acids, chlorates, oxidizing agents (sulfur and oxygen), halogenated hydrocarbons, hydrazine mononitrate, hydroxylamine, ammonium nitrate, barium dioxide, barium nitrate, cadmium, performic acid, manganese chloride, nitric acid, ethyl acetoacetate and tribromoneopentyl alcohol, tellurium, carbon disulfide, lead azide, magnesium and barium nitrate and barium dioxide, selenium, sodium peroxide, potassium nitrate, and water. In humans, a toxic effect results from inhaling 124 mg/m³ of zinc metal/powder for 50 min.
Hazardous Products of Decomposition: Thermal oxidative decomposition of zinc can produce highly toxic fumes. Above 999 °F (537 °C) vaporized zinc burns in air with a blue-green flame to produce zinc oxide fumes.

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists zinc as a carcinogen.

Summary of Risks: Zinc is relatively nontoxic, but when combined with other materials such as oxygen or mineral acids, the resulting compounds can have toxic effects. It is not readily absorbed through the skin, gastrointestinal (GI tract), or lungs. Although most inorganic zinc compounds are potential causes of gastroenteric irritation, a high-level dose is relatively nontoxic when ingested. Zinc is considered essential to life Ingestion of soluble salts may cause nausea and vomiting, sluggishness, and light-headedness. Inhalation of zinc fumes normally generated by zinc and extreme heat may cause *metal fume fever*, which is accompanied by throat dryness and irritation, coughing, weakness, dyspnea, and generalized aching that generally passes within 24 hr. These symptoms usually begin 3 to 10 hr after exposure and resolve within 24 to 48 hr. Inhalation of zinc dust may cause mild irritation to the upper respiratory tract. Prolonged skin contact with zinc may cause a mild, drying dermatitis.

Medical Conditions Aggravated by Long-Term Exposure: Since metallic zinc particulates can be considered a niusance dust, repeated inhalation of zinc dust could lead to respiratory complications.

Target Organs: Respiratory system.

Primary Entry: Inhalation, ingestion.

Acute Effects: Metal fume fever is an acute, self-limiting condition, without recognized complications, aftereffects, or chronic forms. Symptoms appear several hours after exposure. Removal from exposure normally alleviates symptoms with no residual or chronic effects. A degree of tolerance may result from continued exposure, but is quickly lost after a day or two of nonexposure.

Chronic Effects: Zinc and zinc powder have little history of causing chronic effects.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: After rinsing affected area with flooding amounts of water, wash it with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that conscious person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear. **Physician's Note:** Calcium disodium edetate ($CaNa_2$-EDTA) has been used medically to increase the rate of zinc removal from the body; however, this usually results from chronic fume exposure or exposure to zinc salts, not to zinc metal powders.

After first aid, get appropriate in-plant, paramedic, or community medical attention and support.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of powder spills. Eliminate all heat and ignition sources. Cleanup personnel should protect against dust inhalation and eye contact. Use nonsparking tools for cleanup. Sweep or otherwise place the spilled material in an appropriate, pressure-vented, dry-metal container (with lid) for later disposal. Container should be pressure vented. Avoid creating airborne dust conditions.

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

OSHA Designations

Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [* per Clean Water Act, Sec. 307(a)]

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Zinc (fume or dust) is listed as SARA Toxic Chemical (40 CFR 372.65)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: For zinc oxide dust or fume concentrations up to 50 mg/m^3 and 250 mg/m^3, use, respectively, a fume (high-efficiency particulate) respirator or an air-supplied or self-contained respirator with a full facepiece. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.

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

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below established TLVs-TWAs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 103).

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Launder contaminated clothing before wearing. Remove this material from your shoes and equipment. Wash thoroughly before changing to street clothes.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in covered metal containers in a dry, well-ventilated, low fire risk area. Protect containers from physical damage. Never store with acids, halogenated hydrocarbons, or strong alkalis.

Engineering Controls: Avoid breathing dust or fumes. Use good housekeeping and cleaning techniques to minimize airborne particulates and to prevent dust accumulation. Provide suitable training in personal hygiene and in the cause and effect of metal fume fever. Prevent exposure of workers with respiratory problems or gastrointestinal disorders.

Transportation Data (49 CFR 172.102)

IMO Shipping Name: Zinc, powder or dust, nonpyrophoric	**IMO Shipping Name:** Zinc, powder or dust, pyrophoric
IMO Hazard Class: 4.3	**IMO Hazard Class:** 4.2
IMO Label: Dangerous when wet	**IMO Label:** Spontaneously combustible
IMDG Packaging Group: II	**IMDG Packaging Group:** II

***MSDS Collection* References:** 2, 4-11, 24, 31, 39-41, 80, 81,84,85,91, 109

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** Warren Silverman, MD

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GENIUM PUBLISHING CORP.

No. 219

SODIUM METAL

Issued: November 1987

SECTION 1. MATERIAL IDENTIFICATION

24

Material Name: SODIUM METAL

Description (Origin/Uses): Prepared industrially in Down cells and in Castner cells. Used as a dehydrating agent, nuclear reactor coolant, reducing agent, conductor in cables, and in organic synthesis; nonglare lighting for highways, radioactive forms in tracer studies and medicine.

Other Designations: Natrium; Sodium; Sodium, Metallic; Na; NIOSH *RTECS* No. VY0686000; CAS No. 7440-23-5

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

HMIS	
H 3	
F 1	R 2
R 2	I NA
PPG*	S 4
*See sect. 8	K 1

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
Sodium Metal, CAS No. 7440-23-5 Sodium plus water yields sodium hydroxide (NaOH), having the CAS No. 1310-73-2 and the NIOSH *RTECS* No. WB4900000 with the following exposure limits: ACGIH TLV, 1987-88 Ceiling TLV: 2 mg/m³ OSHA PEL 8-Hr TWA: 2 mg/m³ NIOSH REL 15-Min Ceiling: 2 mg/m³	ca 100	Element Sodium: No Exposure Limits Established No Toxicity Data is available for element sodium; however, as Thyroxime, monosodium salt, D-: Rabbit, Oral, TD_{Lo}: 15 mg/kg

SECTION 3. PHYSICAL DATA

Boiling Point: 1621°F (883°C)
Melting Point: 208°F (98°C)
Water Solubility: Reacts Violently with Water
Molecular Weight: 22.99 Grams/Mole
Specific Gravity (H_2O = 1): 0.968
pH: Water Solution Alkaline (pH >7)

Appearance and Odor: Malleable (soft), silver-white solid, oxidizes rapidly in air; waxlike at room temperature. Odorless.

Comments: Solvent solubility: sodium decomposes in alcohol; it is insoluble in ether and benzene, and it dissolves in liquid ammonia to produce a blue solution.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
Flammable Solid	250°F (121°C)	Not Applicable	Not Applicable	Not Applicable

Extinguishing Media: Do *not* use water, "alcohol" foam, carbon dioxide, or halogenated extinguishing agents (Halon®) to put out a fire involving sodium metal. Use graphite powder, soda ash, powdered sodium chloride, or suitable dry powder (Met-L-X® or G-1® graphite powders). Pails are adequate for storing extinguishing agents if the material is kept dry. **Unusual Fire/Explosion Hazards:** Sodium metal is extremely dangerous in contact with moisture or water and releases hydrogen with sufficient heat to cause ignition or explosion. It ignites spontaneously in air or with oxygen, and it burns violently accompanied by explosions that can cause the material to spatter. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Fire fighters should move containers from the fire area if possible (see Genium ref. 85). Sodium metal may reignite after the fire is extinguished. Keep it away from drains or sewers; it may create an additional fire hazard. Preplanning and placement of correct extinguishing media is required. **Comments:** This material is dangerous when exposed to air in a heated environment (fire); it will emit toxic fumes of sodium oxide, which will react with water to produce heat, hydrogen gas, and flammable vapors.

SECTION 5. REACTIVITY DATA

Sodium metal is not stable and may readily undergo violent chemical change without detonation. It will react violently or explosively with water, and it reacts spontaneously in air. **Chemical Incompatibilities:** Sodium metal reacts vigorously or explosively with oxidizing agents. The following materials may cause an explosive reaction: acids (hydrochloric acid, hydrogen fluoride, nitric acid [fuming], and sulfuric acid); air; halides such as aluminum bromide, magnesium chloride, aluminum fluoride, and mercuric iodide; carbon dioxide; ammonia; chlorinated hydrocarbons; hydrogen peroxide; lead oxide; phosphorus; potassium oxides; sulfur; sulfur dioxide; and especially water. **Conditions to Avoid:** Avoid exposing this material to air or moisture. It may ignite spontaneously if it is exposed to moist air. Its violent reaction with water will produce hydrogen gas. **Hazardous Products of Decomposition:** Sodium metal may release these toxic fumes when decomposed: sodium oxide, which can react with moisture or steam to produce heat; sodium hydroxide (corrosive); and flammable hydrogen gas.
Comments: This material is dangerous when exposed to moisture! Keep it dry at all times.

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SECTION 6. HEALTH HAZARD INFORMATION

Sodium metal is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: This material is harmful or fatal if swallowed, inhaled, or absorbed through the skin and mucous membranes. It is corrosive to skin and body tissue. Inhalation may cause upper respiratory tract irritation, inflammation, and pulmonary damage. It may react violently and explosively on contact with wet tissue and generate heat with resultant chemical and thermal burns. The effects of low-dosage exposure are usually reversible after exposure has ended. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Eyes, skin, mucous membranes, respiratory tract. **Primary Entry:** Skin and eye contact. **Acute Effects:** Sodium metal is corrosive to body tissue. Alkalies penetrate the skin slowly, therefore the extent of damage depends on the amount and duration of exposure. It may cause burns, ulcerations, and tissue death (necrosis). Its fumes are highly irritating. Eye contact will cause burns, conjunctivitis, corneal damage, and corneal opacification with possible blindness. Inhalation of dusts or fumes will cause shortness of breath, headache, nausea and vomiting, and nose and respiratory tract irritation (pneumonitis). If swallowed, this material will cause severe pain, vomiting, diarrhea, and possible collapse. **Chronic Effects:** This material may cause chronic dermatitis, mucous membrane irritation, and lung damage. Corrosive effects may result in permanent impairment.

FIRST AID: Eye Contact. Flush eyes, including under the eyelids, promptly and gently with plenty of running water for 15 minutes. **Skin Contact.** Remove sodium metal-contaminated clothing immediately. Wash the affected area with mild soap and water until all the chemical is removed. In case of chemical burn, treat as indicated. **Inhalation.** Remove victim to fresh air. If he is not breathing, give him artificial respiration, preferably mouth to mouth. If breathing is difficult, give him oxygen. **Ingestion.** If swallowed, and victim is conscious, give him water or milk. Never give anything by mouth to someone who is unconscious.

Comments: Sodium metal reacts with moisture to form sodium hydroxide, which is a severe eye, skin, and mucous membrane irritant. Exposure to this may cause permanent eye and skin damage.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Do not touch spilled sodium metal. Shut off ignition sources. Do not get water on spilled material or inside material's container because of the danger of violent and explosive reactions. Shovel small dry spills into a clean, dry container and cover it. Wear an SCBA and heavy chemical-resistant gloves.

Waste Disposal: Do not dilute a spill with liquid or dispose of it down any open drain or sewer. Contact your supplier or a licensed contractor for recommendations. Follow Federal, state, and local regulations.

OSHA Designations

Air Contaminant (29 CFR 1910.1000 Subpart Z): Not Listed

EPA Designations (40 CFR 302.4)

RCRA Hazardous Waste, No. D003 (Reactivity)

CERCLA Hazardous Substance, Reportable Quantity: 10 lbs (4.54 kg)

Comments: CERCLA Ratings (Scale 0-3): Health: 3; Fire: 1; Reactivity: 2; Persistence: 3

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Follow the eye- and face-protection guidelines of 29 CFR 1910.133. Wear chemical splash-proof and dust-resistant safety goggles and/or faceshield with approved safety glasses to prevent eye and face contact. There is a potential for violent spattering when using sodium metal. **Gloves:** Wear appropriate, heavy-duty, chemical-resistant gloves. **Respirator:** Where high levels of sodium metal dust, fume, or sodium hydroxide may exist, wear the self-contained breathing apparatus described in section 4. **Other:** Wear protective chemical-resistant apron, boots, and other appropriate protective clothing. **Ventilation:** Use sodium metal only under a chemical fume hood, under localized ventilation, or where general dilution ventilation is adequate.

Safety Stations: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling because sodium metal is corrosive to eyes and body tissue.

Contaminated Equipment: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Particles may cling to contact lenses, causing corneal injury.

Comments: Practice effective personal hygiene. Keep this material off of your clothes and equipment. Avoid transferring this material from hands to mouth while eating, drinking, or smoking. Do *not* smoke, eat, or drink in any immediate work area. Avoid all contact with sodium metal.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store sodium metal away from sources of heat, ignition, water, and other liquids. Store it away from oxidizers. **Special Handling/Storage:** Protect containers against physical damage. Store this material in airtight containers under an inert atmosphere such as nitrogen or in naphtha or a similar liquid that does not contain water or free oxygen (e.g., coal oil, kerosene, or other liquid hydrocarbons). *Never store sodium metal under halogenated hydrocarbons* such as Freon®, methylene chloride, or 1,1,1-trichloroethane. The storage media is itself a hazard; handle it appropriately. An isolated, well-ventilated, fire-resistant building is recommended for large-quantity storage. Do not store it where automatic sprinklers are present or where water or steam is readily available. Provide enough heat in the storage area to keep material sufficiently dry from condensating moisture. Provide appropriate fire extinguishers for the storage area. Water contamination of storage tanks, reactor vessels, etc., must be scrupulously avoided at all costs. **Comments:** In the absence of water, oxygen, or halides, sodium metal is safe to handle. Remove only that amount of material immediately needed from the storage area. Use a metal container with tightly fitting lid for transport. **Warning:** Sodium metal is a highly reactive material and requires a sustained, conscientious effort by all who work with it for its safe use.

Transportation Data (49 CFR 172.101-2)

DOT Hazard Class: Flammable Solid
DOT Label: Flammable Solid; Dangerous When Wet
DOT Shipping Name: Sodium Metal
IMO Label: Dangerous When Wet
DOT ID No. UN1428
IMO Class: 4.3

References: 1-11, 18, 24, 37, 39, 44, 73, 82, 84, 87-94. OW/PJI

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Approvals

Indust. Hygiene/Safety 5/88

Medical Review 5/88

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GENIUM PUBLISHING CORP.

No. 221

CALCIUM METAL

Issued: November 1987

SECTION 1. MATERIAL IDENTIFICATION

24

Material Name: CALCIUM METAL

Description (Origin/Uses): Produced by electrolysis of calcium chloride. Used in alloys of aluminum, copper, and lead.

Other Designations: Calcicat; Calcium; Ca; NIOSH *RTECS* No. EV8040000; CAS No. 7440-70-2

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

HMIS			
H	1		
F	1	R	2
R	2	I	NA
PPG*		S	3
*See sect. 8		K	0

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
Calcium Metal, CAS No. 7440-70-2	100	Element Calcium: No Exposure Limits Established
Calcium plus water yields calcium hydroxide, $Ca(OH)_2$, having the CAS No. 1305-62-0 and the NIOSH *RTECS* No. EW2800000 with the following data: ACGIH TLV, 1987-88 TLV-TWA: 5 mg/m³		Artificial Isotopes: ^{45}Ca and ^{47}Ca pose a radiation hazard; they emit gamma radiation.

SECTION 3. PHYSICAL DATA

Boiling Point: 2703°F (1484°C)
Melting Point: 1542°F (839°C)
Water Solubility: Reacts Violently with Water*
Molecular Weight: 40.08 Grams/Mole
Specific Gravity (H_2O = 1): 1.5
pH: Water Solution Alkaline (pH >7)

*Soluble in water forming the hydroxide; soluble in acids forming salts.

Appearance and Odor: Silver-white, crystalline, lustrous metal; tarnishes to blue-gray-white on exposure to air. Odorless.

Comments: Calcium metal is soluble in alcohol, ammonia, and dilute acids.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
Flammable Solid	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Extinguishing Media: Do *not* use water, foam, or halogenated hydrocarbons such as Halon® or carbon tetrachloride to extinguish fires involving calcium metal. Carbon dioxide and dry chemical are ineffective. Use only graphite powder, soda ash, powdered sodium chloride, or an appropriate metal-fire-extinguishing dry powder such as Met-L-X®. For large fires, withdraw from the area and let the fire burn (see Genium ref. 85). **Unusual Fire/Explosion Hazards:** Calcium metal is a flammable solid. It is extremely dangerous when wet; keep it dry. This material forms calcium hydroxide and hydrogen gas (explosion hazard) when wet. It may form toxic fumes of calcium oxide. This substance can also develop explosive pressures in closed containers. It reacts with wet extinguishing agents (water, alcohol, halogens, and possibly carbon dioxide). Its contact with alkali hydroxides or carbonates may result in detonation. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Fire fighters should move containers from the fire area if this can be done without risk. Do not use water or foam! Use dry powders only. Fire fighters should wear full protective gear. This kind of fire may produce irritating or poisonous gases. **Comments:** Finely divided calcium metal particles may ignite spontaneously in air or oxygen at room temperature. Fires may reignite after they have been extinguished. Runoff of waste material into a sewer or drain may create an additional fire or explosion hazard.

SECTION 5. REACTIVITY DATA

Calcium metal is not stable. Hazardous polymerization is not known to occur.

Chemical Incompatibilities: Hazardous reactions involving this material occur with air, moist air, water, acids, strong oxidizing agents, alcohols, and halogens. Contact with alkali hydroxides or carbonates may cause detonation.

Conditions to Avoid: This material may ignite spontaneously if exposed to air or kept in the presence of moisture. Store in airtight containers or under oil (see sect. 9). Calcium metal can develop explosive pressures in containers; keep them dry at all times.

Hazardous Products of Decomposition: Toxic calcium oxide fumes, which can react with water to produce heat, calcium hydroxide (corrosive), and flammable hydrogen gas (explosion hazard).

Comments: Calcium metal reacts with water considerably less than sodium metal does.

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SECTION 6. HEALTH HAZARD INFORMATION

Calcium metal is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: This material is harmful or fatal if swallowed; inhaled as a mist (calcium hydroxide), dust, or fume; or absorbed through the skin or mucous membranes. Solid calcium metal will cause skin and eye burns because it reacts with moisture to form corrosive calcium hydroxide. Fumes from burning calcium metal (calcium oxide) are highly irritating to skin, eyes, and mucous membranes, including the upper respiratory tract. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Eyes, skin, mucous membranes (upper respiratory tract). **Primary Entry:** Inhalation, ingestion, skin and eye contact. **Acute Effects:** Corrosive and irritating to body tissue. May cause skin burns and corneal damage. Inhalation of dust or fume may cause respiratory irritation, cough, difficulty in breathing (dyspnea), and chemical pneumonitis. **Chronic Effects:** Prolonged inhalation of dust or fume may cause severe mucous membrane irritation, chemical pneumonitis.

FIRST AID: Eye Contact. Flush eyes, including under the eyelids, promptly and gently with plenty of running water for 15 minutes. If burns are present seek medical help immediately. **Skin Contact.** Remove calcium metal-contaminated material immediately with a dry cloth. Wash with large amounts of water until all of the chemical is removed. In case of chemical burn, treat as indicated. **Inhalation.** Remove victim to fresh air; restore and/or support his breathing as needed. Keep him warm and at rest. **Ingestion.** If swallowed, and victim is conscious, give him large amounts of water to dilute the alkali. Do not induce vomiting. A gastric lavage can be used by trained staff. Never give anything by mouth to someone who is unconscious.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Do not touch spilled calcium metal. Wear protective apparel. Do not smoke or place flame or ignition sources near a spill area. Do not allow water to touch spilled material or to get inside containers. Use a cover (plastic sheet) to prevent water or rain from dissolving spilled material or to prevent its spreading. Isolate hazard area and keep nonessential personnel away from spill or leak site. Shovel small dry spills into a dry container and cover it tightly. Move containers away from spill to a safe area. Take up small spills with sand or an absorbent material and contain it as described above. Dike the flow of large calcium metal and water spills with soil, sandbags, or concrete. Keep the waste from entering drains or open sewers. Wear fully protective gear.

Waste Disposal: You may dilute residual spilled material with water jets. Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Air Contaminant (20 CFR 1910.1000 Subpart Z): Not Listed
EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste, No. D003 (Reactivity)
CERCLA Hazardous Substance: Not Listed

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Follow the eye- and face-protection guidelines of 29 CFR 1910.133. Wear chemical splash-proof and dust-resistant safety goggles and/or a faceshield (8" minimum) with approved safety glasses to prevent eye and face contact with calcium metal.

Gloves: Wear appropriate, heavy-duty, chemical-resistant gloves. **Respirator:** Where uncomfortable or nuisance levels of calcium metal dust exist, a dust/mist respirator can be used. Where high levels of calcium metal dust or fume or calcium hydroxide, calcium oxide, or hydrogen may exist (as in a fire situation or spill), use only an SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode.

Special Considerations: Wear protective clothing; a rubber apron may be appropriate for the particular work situation.

Ventilation: Work with this material only under a chemical fume hood with localized ventilation or where general dilution ventilation is adequate.

Safety Stations: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling because calcium metal is corrosive to eyes and body tissue.

Contaminated Equipment: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Particles may cling to contact lens surfaces, causing corneal injury.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store calcium metal away from sources of heat, ignition (sparks and open flame), water, combustible material, acids, halogens, alcohols, and other liquid chemicals. Store it away from oxidizers.

Special Handling/Storage: Protect containers against physical damage. Store this material in airtight containers under an inert atmosphere such as nitrogen or argon or under liquid hydrocarbons (naphtha, kerosene, or coal oil). *Never store it under halogenated hydrocarbons* such as Freon®. Avoid high temperatures. An isolated, well-ventilated, fire-resistant building is recommended for large-quantity storage. Do not store material near automatic water sprinklers or where water or steam is present. Provide enough heat in the storage area to keep material sufficiently dry. **Comments:** Calcium metal is air sensitive. Keep it in tightly closed containers at all times when not in use. Remove only the amount of calcium metal from its storage container that is immediately necessary. Use a metal container with a tightly fitting lid or well-stoppered glass bottles for storage and transport. Scrupulously avoid water contamination of storage tanks, reactor vessels, testing areas, etc.

Transportation Data (49 CFR 172.101-2)
DOT Hazard Class: Flammable Solid **DOT Shipping Name:** Calcium Metal **DOT ID No.** UN1401
DOT Label: Flammable Solid; Dangerous When Wet **IMO Label:** Dangerous When Wet **IMO Class:** 4.3
Additional DOT Requirements: Keep Cold and Dry. Segregation is the same as for flammable solids labeled Dangerous When Wet.

References: 1-11, 12, 18, 24, 37, 39, 44, 73, 82, 84, 87-94. OW/PJI

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Approvals
Indust. Hygiene/Safety 5/85
Medical Review 5/85

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Material Safety Data Sheets Collection:

Sheet No. 296
Arsenic and Compounds

Issued: 4/90

Section 1. Material Identification

Arsenic Description: Obtained from flue dust of copper and lead smelters as white arsenic (arsenic trioxide). Reduction with charcoal and sublimation in an N_2 current yields pure arsenic. Metallic arsenic is used for hardening copper, lead, and alloys; as a doping agent in germanium and silicon solid-state products, special solders, and medicine; and to make gallium arsenide for dipoles and other electronic devices. Arsenic compounds are used in manufacturing certain types of glass; in textile printing, tanning, taxidermy, pharmaceuticals, insecticides and fungicides, pigment production, and antifouling paints; and to control sludge formation in lubricating oils. Arsenic trioxide is the source for 97% of all arsenic products.
Other Designations: CAS No. 7440-38-2; arsen; arsenic black; As; gray arsenic; metallic arsenic.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.

R 1
I 4
S 2
K 0

Genium

HMIS
H 3
F 2
R 2
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Arsenic and soluble compounds, as As

OSHA PEL
8-hr TWA: 0.5 mg/m³,* 0.01 mg/m³†

ACGIH TLV, 1989-90
TLV-TWA: 0.2 mg/m³

NIOSH REL, 1987
Ceiling: 0.002 mg/m³

Toxicity Data‡
Man, oral, TD_{Lo}: 76 mg/kg administered intermittently over a 12-year period affects the liver (tumors) and blood (hemorrhage)
Man, oral: 7857 mg/kg administered over 55 years produces gastrointestinal (in the structure or function of the esophagus), blood (hemorrhage), and skin and appendage (dermatitis) changes
Rat, oral, TC_{Lo}: 605 µg/kg administered to a 35-week pregnant rat affects fertility (pre- and post-implantation mortality)

* Organic compounds.
† Inorganic compounds.
‡ See NIOSH, *RTECS* (CG0525000), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data*

Boiling Point: sublimes at 1134 °F/612 °C
Melting Point: 1497 °F/814 °C
Vapor Pressure: 1 mm at 702 °F/372 °C (sublimes)
Atomic Weight: 74.92
Density: 5.724 at 57 °F/14 °C
Water Solubility: Insoluble†

Appearance and Odor: A brittle, crystalline, silvery to black metalloid. Odorless.

* This data pertains to arsenic only.
† Arsenic is soluble in nitric acid (HNO_3).

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: Use dry chemical, CO_2, water spray, or foam to fight fires.
Unusual Fire or Explosion Hazards: Flammable and slightly explosive in the form of dust when exposed to heat or flame.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Arsenic is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Arsenic can react vigorously on contact with powerful oxidizers such as bromates, peroxides, chlorates, iodates, lithium, silver nitrate, potassium nitrate, potassium permanganate, and chromium (VI) oxide. This material is also incompatible with halogens, bromine azide, palladium, dirubidium acetylide, zinc, and platinum.
Hazardous Products of Decomposition: Thermal oxidative decomposition of arsenic and its compounds produces irritating or poisonous gases.

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Section 6. Health Hazard Data

Carcinogenicity: The IARC, NTP, and OSHA list arsenic as a human carcinogen (Group 1). This evaluation applies to arsenic and arsenic compounds as a whole, and not necessarily to all individual chemicals within the group. Studies report that both the trivalent and pentavalent compounds are strongly implicated as causes of skin, lung, and lymphatic cancers. Experimental studies have shown that arsenic has tumorigenic and teratogenic effects in laboratory animals.
Summary of Risks: Arsenic compounds are irritants of the skin, mucous membranes, and eyes. The moist mucous membranes are most sensitive to irritation. Prolonged contact results in local hyperemia (blood congestion) and later vesicular or pustular eruption. Epidermal carcinoma is a reported risk of exposure. Peripheral neuropathy (degenerative state of the nervous system) is common after acute or chronic arsenic poisoning. Symptoms include decreased sensation to touch, pinprick, and temperature; loss of vibration sense; and profound muscle weakness and wasting. Other complications of acute and chronic arsenic poisoning are encephalopathy (alterations of brain structure) and toxic delirium.
Medical Conditions Aggravated by Long-Term Exposure: Damage to the liver, nervous, and hematopoietic (responsible for the formation of blood or blood cells in the body) system may be permanent. Pulmonary and lymphatic cancer may also occur.
Target Organs: Liver, kidneys, skin, lungs, lymphatic system.
Primary Entry Routes: Inhalation, ingestion of dust and fumes, via skin absorption.
Acute Effects: Acute industrial intoxication is more likely to arise from inhalation of arsine. However, with corrosive arsenical vapors, conjunctivitis, eyelid edema, and even corneal erosion may result. Inhalation may result in nasal irritation with perforation of the septum, cough, chest pain, hoarseness, pharyngitis, and inflammation of the mouth. If ingested, metallic or garlic taste, intense thirst, nausea, vomiting, abdominal pain, diarrhea, and cardiovascular arrhythmias (heartbeat irregularities) may occur. Symptoms generally occur within 30 minutes, but may be delayed for several hours if ingested with food. Acute poisoning may result in acute hemolysis (breakdown of red blood cells).
Chronic Effects: Chronic symptoms include weight loss, hair loss, nausea, and diarrhea alternating with constipation, palmar and plantar hyperkeratoses (thickening of the corneous layer of skin on palms and soles of feet), and skin eruptions, and peripheral neuritis (inflammation of the nerves). Leukemia, bone marrow depression, or aplastic anemia (dysfunctioning of blood-forming organs) may occur after chronic exposure.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: If emesis is unsuccessful after two doses of Ipecac, consider gastric lavage. Monitor urine arsenic level. Alkalinization of urine may help prevent disposition of red cell breakdown products in renal tubular cells. If acute exposure is significant, maintain high urine output and monitor volume status, preferably with central venous pressure line. Abdominal X-rays should be done routinely for all ingestions. Chelation therapy with BAL, followed by n-penicillamine is recommended, but specific dosing guidelines are not clearly established.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of spill, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against dust inhalation and contact with skin and eyes. Use nonsparking tools. With a clean shovel, scoop material into a clean, dry container and cover. Absorb liquid material with sand or noncombustible inert material and place in disposal containers. Do not release to sewers, drains, or waterways. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations*
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance† (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [† per Clean Water Act, Sec. 307(a); per Clean Air Act, Sec. 112]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations‡
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

* Designations for arsenic only.
‡ Listed as arsenic organic compounds (as As).

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PELs, ACGIH TLVs, and NIOSH REL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed, properly labeled, containers in a cool, well-ventilated area away from all incompatible materials (Sec. 5) and heat and ignition sources. Protect containers from physical damage.

Engineering Controls: Avoid inhalation or ingestion of dust and fumes, and skin or eye contact. Practice good personal hygiene and housekeeping procedures. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program with training, maintenance, inspection, and evaluation. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Provide preplacement and annual physical examination with emphasis on the skin, respiratory system, and blood.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Arsenic, solid
DOT Hazard Class: Poison B
ID No.: UN1558
DOT Label: Poison
DOT Packaging Requirements: 173.366
DOT Packaging Exceptions: 173.364

IMO Shipping Name: Arsenic, metallic
IMO Hazard Class: 6.1
IMO Label: Poison
IMDG Packaging Group: II
ID No.: UN1558

MSDS Collection **References:** 7, 26, 38, 53, 73, 85, 87, 88, 89, 100, 103, 109, 123, 124, 126, 127, 130, 136, 138
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD M4

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Material Safety Data Sheets Collection:

Sheet No. 297
Barium and Compounds

Issued: 4/90

Section 1. Material Identification

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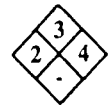
Barium and Compounds Description: Produced by reducing barium oxide with aluminum or silicon in a vacuum at high temperature. The minerals barite ($BaSO_4$) and witherite ($BaCO_3$) are the primary sources of barium. Used as lubricant for anode rotors in X-ray tubes; a deoxidizer for copper; an extender in paints; a loader for paper, soap, rubber, and linoleum; a carrier for radium; a fire extinguisher for uranium or plutonium fires; a rodenticide; a stabilizer and mold lubricant in the rubber and plastics industries; a flux for magnesium alloys; getter alloys in vacuum tubes; and in spark-plug alloys and Frary's metal. Important barium compounds include carbonate (ceramics, rodenticide), sulfate (pigment and filler), hydroxide (water treatment, ceramics), nitrate (pyrotechnics), chloride (chemicals), chromate (pigments), oxide (lubricants), and peroxide (bleach).

Other Designations: CAS No. 7440-39-3; Ba.

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

R 2
I 3
S 2
K 4

Genium



HMIS
H 2
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PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Barium, ca 100%

OSHA PEL
8-hr TWA: 0.5 mg/m³ (Barium, soluble compounds, as Ba)

NIOSH REL, 1987
None established

Toxicity Data*
None listed

ACGIH TLV, 1989-90
TLV-TWA: 0.5 mg/m³ (Barium, soluble compounds, as Ba)

* Monitor *RTECS* (CQ8370000), for additional future data.

Section 3. Physical Data*

Boiling Point: 2984 °F/1640 °C
Melting Point: 1337 °F/725 °C
Vapor Pressure: 10 mm Hg at 1920 °F/1049 °C
Molecular Weight: 137.33 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 3.51 at 68 °F/20 °C
Water Solubility: Insoluble

Appearance and Odor: A silver white metal that is slightly lustrous and somewhat malleable.
Comment: Barium has a distinctive property of absorbing gases.

* Physcial data are for barium only.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: *Do not* use water or foam. For small fires, use dry chemical, soda ash, lime, or sand. For large fires, withdraw from area and let fire burn.

Unusual Fire or Explosion Hazards: In the powder form, barium is flammable at room temperature. It is also explosive in the form of dust when exposed to heat, flame, or by chemical reaction. The chlorate, peroxide, and nitrate compounds are reactive and may present fire hazards in storage and use.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and fully encapsulating suit. Barium may ignite itself if exposed to air. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Barium is stable at room temperature under special storage and handling conditions (Sec. 9). If the free metal is exposed to air, an explosion hazard exists because hydrogen is liberated. Barium compounds are more stable than elemental barium. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Barium reacts violently with water, carbon tetrachloride, trichloroethylene, fluorotrichloromethane, and tetrachloroethylene. This material is incompatible with acids, trichloroethylene and water, trichlorotrifluoroethane, 1,1,2-trichloro trifluoro ethane, and bromotrichloroethane. Barium is extremely reactive and reacts readily with halogens and ammonia. Barium compounds are not as reactive as elemental barium. See MSDSs 40, 119, 132, 173, 181, and 251 for specific chemical incompatibilities.

Conditions to Avoid: Avoid heating barium in hydrogen to about 392 °F/200 °C since it reacts violently and forms barium hydride (BaH_2). An explosion hazard exists if the free metal is exposed to moist air or cold water because hydrogen is liberated.

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Section 6. Health Hazard Data

Carcinogenicity: Although the NTP, IARC, and OSHA do not list barium as a carcinogen, the IARC lists barium chromate (VI) as a carcinoge
Summary of Risks: Barium presents mainly an explosion hazard. However, soluble compounds of barium by the oral route are highly toxic and the fatal dose of the chloride has been stated to be 0.8 to 0.9 g. Death may occur from a few hours to a few days. The soluble barium compou exert a profound effect on skeletal, arterial, intestinal, bronchial, and particularly cardiac muscle. Effects on the hematopoietic system (responsible for the formation of blood or blood cells in the living body) and the cerebral cortex are also noted. Poisoning may also occur if the dust of soluble compounds is inhaled. Certain compounds of barium are irritants of the skin, eyes, and mucous membranes. Barium oxide and barium hydroxide, strongly alkaline in aqueous solution, cause severe skin irritation and burns of the eye. Inhalation of insoluble barium produces a benign pneumoconiosis (baritosis). The half-life of barium in bone has been estimated at 50 days.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, mucous membranes, lung, heart.
Primary Entry Routes: Inhalation of dust or fume, ingestion, skin or eye contact.
Acute Effects: Systemic absorption from ingestion causes gastroenteritis (inflammation of the stomach lining and the intestines), slow pulse rate (heart may stop while contracting), muscle spasm, and hypokalemia (potassium deficiency in the blood). Inhalation causes coughing, bronchial irritation, and pneumoconiosis. Contact with soluble salts causes dermatitis, irritation of the eyes and mucous membranes, and burns. During radiological examination, intraperitoneal (in the abdomen) or intrathoracic (in the chest) barium sulfate contamination resulting from a complication rupture may cause a significant inflammatory response.
Chronic Effects: Although baritosis (caused by inhaling barium sulfate) produces nodular opacities on chest X-rays, there is no evidence of clinical illness or bodily dysfunction.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Consider using calcium gluconate for muscular spasms. Consider gastic lavage followed by saline catharsis if soluble barium compounds are ingested. Institute cardiac monitoring for all significant ingestions of soluble barium salts.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of spill. Immediately shut off all heat and ignition sources and evacuate hazard area. Cleanup personnel should protect against dust inhalation and contact with skin, eyes, and mucous membranes. For small dry spills, use a clean shovel to place material into a clean, dry container with a cover. For a large dry spill, cover with a plastic sheet to minimize spreading. For liquid spills, cov with sand or other noncombustible material and place in disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations*
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations *
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

*Designations for barium only.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store under inert gas, petroleum, or oxygen-free liquid in a cool, dry, well-ventilated area away from all incompatibles (Sec. 5).
Engineering Controls: Barium metal itself presents mainly an explosion hazard. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Use nonsparking tools. Proper storage is essential. Avoid dust inhalation and skin, eye, and mucous membrane contact. All processes should be enclosed and/or exhaust ventilation installed to keep the dust concentrations below the recommended levels. Practice good personal hygiene and housekeeping procedures. Preemployment and periodic medical examinations should be given to workers exposed to barite dust. Prevent exposing individuals with respiratory disorders.

Transportation Data (49 CFR 172.102)
IMO Shipping Name: Barium alloys, pyrophoric
IMO Hazard Class: 4.2
IMO Label: Spontaneously combustible
IMDG Packaging Group: II
ID No.: UN1854

***MSDS Collection* References:** 7, 26, 38, 73, 85, 87, 89, 100, 103, 109, 123, 124, 126, 127, 133, 136, 138, 139
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD F4

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Material Safety Data Sheets Collection:

Sheet No. 300
Acetone

Issued: 11/77 Revision: F, 9/92

Section 1. Material Identification

Acetone (CH_3COCH_3) **Description:** Derived by the dehydrogenation or oxidation of isopropyl alcohol with a metallic catalyst, the oxidation of cumene, the vapor phase oxidation of butane; and as a by-product of synthetic glycerol production. Used as a solvent for paint, varnish, lacquer, fat, oil, wax, resin, rubber, plastic, and rubber cement; to clean and dry parts of precision equipment; in the manufacture of chemicals (methyl isobutyl ketone, methyl isobutyl carbinol, methyl methacrylate, bisphenol-A, acetic acid (ketene process), mesityl oxide, diacetone alcohol, chloroform, iodoform, bromoform), explosives, aeroplane dopes, rayon, photographic films, isoprene; acetylene gas storage cylinders; in purifying paraffin; in nail polish remover; in the extraction of various principles from animal and plant substances; in hardening and dehydrating tissues; in cellulose acetate (especially as spinning solvent); as a solvent for potassium iodide and permanganate; as a delusterant for cellulose acetate fibers; in the specification testing of vulcanized rubber products.

Other Designations: CAS No. 67-64-1, AI3-01238, Chevron acetone, dimethylformaldehyde, dimethylketal, dimethyl ketone, β-ketopropane, methyl ketone, propanone, 2-propanone, pyroacetic acid, pyroacetic ether.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Acetone vapor is a dangerous fire and explosion hazard. High vapor concentrations may produce narcosis (unconsciousness). Prolonged or repeated skin contact causes dryness, irritation, and mild dermatitis.

NFPA
R 1
I 1
S 1*
K 3
* Slight skin absorption

HMIS
H 1
F 3
R 0
PPE*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Acetone, 99.5% plus 0.5% water

1991 OSHA PELs *
8-hr TWA: 750 ppm (1800 mg/m³)
15-min STEL: 1000 ppm (2400 mg/m³)

1990 IDLH Level
20,000 ppm

1990 NIOSH REL
TWA: 250 ppm (590 mg/m³)

1992-93 ACGIH TLVs
TWA: 750 ppm (1780 mg/m³)
STEL: 1000 ppm (2380 mg/m³)

1990 DFG (Germany) MAK
1000 ppm (2400 mg/m³)
Category IV: Substances eliciting very weak effects (MAK >500 mL/m³)
Peak: 2000 ppm, 60 min, momentary value†, 3 peaks/shift

1985-86 Toxicity Data ‡
Human, eye: 500 ppm
Human, inhalation, TC_{Lo}: 500 ppm produced olfaction effects, conjunctival irritation, and other changes involving the lungs, thorax, or respiration.
Rat, oral, LD_{50}: 5800 mg/kg altered sleep time and produced tremors.
Mammal, inhalation, TC_{Lo}: 31500 µg/m³/24 hr administered to pregnant female from the 1st to 13th day of gestation produced effects on fertility (post-implantation mortality).

* In the cellulose acetate fiber industry, enforcement of the OSHA TWA for "doffers" was stayed on 9/5/89 until 9/1/90; the OSHA STEL *does not* apply to that industry.
† Momentary value is a level which the concentration should never exceed.
‡ See NIOSH, *RTECS* (AL3150000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 133.2 °F (56.2 °C) at 760 mm Hg
Freezing Point: -139.6 °F (-95.35 °C)
Vapor Pressure: 180 mm Hg at 68 °F (20 °C), 400 mm Hg at 103.1 °F (39.5 °C)
Saturated Vapor Density (Air = 1.2 kg/m³, 0.075 lb/ft³): 1.48 kg/m³, .093 lb/ft³
Refractive Index: 1.3588 at 20 °C
Appearance and Odor: Colorless, highly volatile liquid; sweetish odor.
* Odor thresholds recorded as a range from the lowest to the highest concentration.

Molecular Weight: 58.08
Specific Gravity: 0.7899 at 20 °C/4 °C
Water Solubility: Soluble
Other Solubilities: Alcohol, benzene, dimethyl formamide, chloroform, ether, and most oils.
Odor Threshold: 47.5 mg/m³ (low), 1613.9 mg/m³ (high)*

Section 4. Fire and Explosion Data

Flash Point: 0 °F (-18 °C), CC	Autoignition Temperature: 869 °F (465 °C)	LEL: 2.6% v/v	UEL: 12.8% v/v

Extinguishing Media: *Do not* extinguish fire unless flow can be stopped. For small fires, use dry chemical, carbon dioxide (CO_2), water spray or alcohol-resistant foam. For large fires, use water spray, fog, or alcohol-resistant foam. Use water in flooding quantities as fog because solid streams may be ineffective. **Unusual Fire or Explosion Hazards:** Acetone is a dangerous fire and explosion hazard; it is a Class IB flammable liquid. Vapors may travel to a source of ignition and flash back, fire-exposed containers may explode, and a vapor explosion hazard may exist indoors, outdoors, or in sewers. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides limited protection. If feasible, remove all fire-exposed containers. Otherwise, apply cooling water to sides of containers until well after fire is extinguished. If the fire becomes uncontrollable or container is exposed to direct flame, consider evacuation of a one-third mile radius. In case of rising sound from venting safety device or any discoloration of tank during fire, withdraw immediately. For massive cargo fires, use unmanned hose holder or monitor nozzles. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Acetone is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Acetone may form explosive mixtures with hydrogen peroxide, acetic acid, nitric acid, nitric acid + sulfuric acid, chromic anhydride, chromyl chloride, nitrosyl chloride, hexachloromelamine, nitrosyl perchlorate, nitryl perchlorate, permonosulfuric acid, thiodiglycol + hydrogen peroxide. Acetone reacts vigorously with oxidizing materials and ignites on contact with activated carbon, chromium trioxide, dioxygen difluoride + carbon dioxide, and potassium-*tert*-butoxide. Other incompatibles include air, bromoform, bromine, chloroform + alkalies, trichloromelamine, and sulfur dichloride. **Conditions to Avoid:** Keep acetone away from plastic eyeglass frames, jewelry, pens, pencils, and rayon garments. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of acetone can produce CO_2 and carbon monoxide (CO).

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list acetone as a carcinogen. **Summary of Risks:** Acetone has been placed among solvents of comparatively low acute and chronic toxicities. In industry, the most common effects reported are headache from prolonged vapor inhalation and skin irritation resulting from its defatting action. Exposures to less than 1000 ppm acetone vapor produces only slight eye, nose, and throat irritation. Acetone does not have sufficient warning properties to prevent repeated exposures. It is narcotic at high concentrations, i.e., above 2000 ppm. Concentrations above 12000 ppm cause loss of consciousness.

Continue on next page

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Section 6. Health Hazard Data,*continued*

Medical Conditions Aggravated by Long-Term Exposure: None reported. **Target Organs:** Respiratory and central nervous systems, skin. **Primary Entry Routes:** Inhalation, skin and eye contact, ingestion. Liquid acetone is slowly absorbed through the skin. **Acute Effects:** Human systemic effects by inhalation include eye, nose and throat irritation; nausea and vomiting; changes in EEG (electroencephalogram) and carbohydrate metabolism; muscle weakness; drunken behavior; mental confusion and visual disturbance. In extreme cases, breathing high concentrations may produce coma. Human systemic effects by ingestion include gastrointestinal irritation, kidney damage (often indicated by albumin and red and white blood cells in the urine), liver damage (indicated by high levels of urobilin and early appearance of bilirubin), coma, metabolic changes, and systemic effects described for inhalation. Direct eye contact by liquid acetone may produce painful burning and stinging; watering of eyes; conjuctival inflammation; and corneal injury. Skin contact produces a cold feeling, dryness, and mild irritation.
Chronic Effects: Cases of chronic poisoning resulting from prolonged exposure to low concentrations of acetone are rare. Workers exposed to 1000 ppm, 3 hrs per day for 7-15 yrs, complained of dizziness, asthenia (lack or loss of strength), and chronic inflammation of the airways, stomach, and duodenum. Prolonged or repeated skin contact with liquid acetone may defat the skin and cause eczematoid dermatitis.
FIRST AID
Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Carefully dispose of contaminated clothing because it may pose a fire hazard. **Inhalation:** Remove exposed person to fresh air, monitor for respiratory distress, and administer 100% humidified supplemental oxygen as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. **After first aid, get appropriate in-plant, paramedic, or community medical support.**
Note to Physicians: In symptomatic patients, monitor serum and urine acetone, fluid intake, blood glucose, and arterial pH. Because of the prolonged elimination half-life of acetone, the symptomatic patient may need medical supervision for many hours (up to 30 hrs). Patients may develop hyperglycemia and ketosis mimicking acute diabetic coma. The hyperglycemia may persist for several days following acute exposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against inhalation and skin or eye contact. If feasible and without risk, stop leak. Use water spray to reduce vapor, but it may not prevent ignition in closed spaces. For small spills, take up with sand or other noncombustible absorbent material and using nonsparking tools, place into containers for later disposal. For large spills, dike far ahead of liquid spill for later disposal. Do not release to sewers or waterways. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Toxicity:** LC_{50} *Salmo gairdneri* (rainbow trout): 5540 mg/L/96 hr at 54 °F (12 °C). LC_{50} (oral) Ring-necked pheasant: >40,000 ppm. **Environmental Degradation:** Acetone biodegrades when released into the environment. The biological oxygen demand for 5 days (BOD5) is 46-55%. **Soil Absorption/Mobility:** Acetone volatilizes, leaches, and biodegrades if released on soil. **Disposal:** Acetone is a good candidate for fluidized bed, rotary kiln incineration, or catalytic oxidation. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): Hazardous Waste No. U002 (Ignitability), (40 CFR 261.31): F003 (spent solvent)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 5000 lb (2270 kg) [* per Clean Water Act, Sec. 311(b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditi[illegible]evel of airborne contamination, and presence of sufficient oxygen. For concentrations < 1000 ppm, wear any chemical cartridge respirator w[illegible]ic vapor cartridge(s) and wear eye protection to avoid irritation or damage. For concentrations <6250 ppm, wear any supplied-air respirat[illegible]ted in a continuous-flow mode. For concentrations < 12,500 ppm, wear any air-purifying, full-facepiece respirator (gas mask) with a chin-sty[illegible]nt- or back-mounted organic vapor canister. For concentrations < 20,000 ppm, wear any supplied-air respirator that has a full facepiece and is [illegible]erated in a pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Polyethylene/ethylene vinyl alcohol, Teflon, or butyl rubber with breakthrough times > 8 hr is recommended for PPE . **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry well-ventilated area away from heat, sparks, flames, and other incompatibles. Keep large stocks away from inhabited buildings. Use non-sparking tools to open containers. Keep dry chemical or CO_2 extinguishers on hand in case of fire. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all containers and equipment during fluid transfer. For bulk storage rooms, install electrical equipment, Class I, Group D. **Administrative Controls:** Consider preplacement and periodic medical examinations with emphasis on the skin and respiratory tract. Also consider liver and kidney function tests and urinalysis.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Acetone	**Packaging Authorizations**	**Quantity Limitations**	**Vessel Storage Requirements**
DOT Hazard Class: 3	**a) Exceptions:** 173.150	**a) Passenger, Aircraft, or Railcar:** 5L	**Vessel Stowage:** B
ID No.: UN1090	**b) Non-bulk Packaging:** 173.202	**b) Cargo Aircraft Only:** 60L	**Other:** --
DOT Packaging Group: II	**c) Bulk Packaging:** 173.242		
DOT Label: Flammable Liquid			
Special Provisions (172.102): T8			

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 176, 180
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD

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Material Safety Data Sheets Collection:
Sheet No. 303
Methyl Ethyl Ketone
Issued: 9/79 Revision: D, 5/93

Section 1. Material Identification

Methyl Ethyl Ketone ($CH_3CH_2COCH_3$) Description: Derived by dehydrogenation or selective oxidation of *sec*-butyl alcohol; from mixed *n*-butylenes and sulfuric acid, followed by distillation to separate *sec*-butyl alcohol and then dehydrogenation; or by controlled oxidation of butane. Used as a solvent for printing inks and cellulose compounds (nitrocellulose in particular), constituent of dewaxing compositions; in the manufacture of acrylic and vinyl surface coatings, paint removers, cements and adhesives, artificial leather, cosmetics, lubricating oils, pharmaceuticals, smokeless powder and explosives, and cleaning fluids.

R 1
I 2
S 2*
K 4
* Skin absorption

NFPA
3
1 0
–

HMIS
H 2
F 3
R 0
PPE†
† Sec. 8

Other Designations: CAS No. 78-93-3, 2-butanone, ethyl methyl ketone, methylacetone, 2-oxobutane.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.
Cautions: Methyl ethyl ketone is a flammable liquid. Vapors are irritating to the eyes and respiratory tract. It potentiates the neurotoxic potential of other chemicals and some findings suggest it may be neurotoxic itself.

Section 2. Ingredients and Occupational Exposure Limits

Methyl ethyl ketone, ca 100%

1992 OSHA PELs
Transitional Limit
8-hr TWA: 200 ppm (590 mg/m^3)
Final Rule Limits
8-hr TWA: 200 ppm (590 mg/m^3)
15-min STEL: 300 ppm (885 mg/m^3)

1992 NIOSH RELs
TWA: 200 ppm (590 mg/m^3)
STEL: 300 ppm (885 mg/m^3)

1993-94 ACGIH TLVs
TWA: 200 ppm (590 mg/m^3)
STEL: 300 ppm (885 mg/m^3)

1991 DFG (Germany) MAK
TWA: 200 ppm (590 mg/m^3)
Half-Life: < 2 hr
Category II: Substances with systemic effects
Peak Exposure Limit: 400 ppm, 30 min. average value, 4/shift

1992 Toxicity Data*
Rabbit, skin: 500 mg/24 hr caused severe irritation.
Rat, oral, LD_{50}: 2737 mg/kg
Rat, inhalation, TC_{Lo}: 3000 ppm/7 hr from 6 to 15 days of pregnancy caused craniofacial abnormalities (including nose and tongue) as well as developmental abnormalities of the urogenital system and homeostasis.
Human, inhalation, TC_{Lo}: 100 ppm/5 min caused eye irritation and respiratory changes.

1990 IDLH Level
3000 ppm

* See NIOSH, *RTECS* (EL6475000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 176 °F (80 °C)
Melting Point: -122.6 °F (-85.9 °C)
Vapor Pressure: 71.2 mm Hg at 68 °F (20 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.085 lb/ft^3 or 1.368 kg/m^3
Bulk Density: 6.71 lb/gal
Refraction Index: 1.379 at 68 °F (20 °C)
Critical Temperature: 504 °F (262 °C)
Critical Pressure: 41 atm

Molecular Weight: 72.1
Density: 0.8045 g/mL at 68 °F (20 °C)
Water Solubility: MEK in water = 28%; water in MEK = 12.5%
Other Solubilities: Soluble in alcohol, benzene, ether, and fixed oils.
Surface Tension: 24.6 dyne/cm at 68 °F (20 °C)
Ionization Potential: 9.54 eV
Viscosity: 0.4 cP at 77 °F (25 °C)
Relative Evaporation Rate (ether = 1): 2.7
Octanol/Water Partition Coefficient: log Kow = 0.26 to 0.29

Appearance and Odor: Colorless, volatile, liquid with a sweet mint or acetone-like odor. The odor threshold is 25 ppm.

Section 4. Fire and Explosion Data

Flash Point: 16 °F (-9 °C)	**Autoignition Temperature:** 759 °F (404 °C)	**LEL:** 1.4% at 200 °F (93 °C)	**UEL:** 11.4% at 200 °F (93 °C)

Extinguishing Media: A Class 1B flammable liquid. For small fires, use dry chemical, carbon dioxide, water spray, or alcohol-resistant foam. For large fires, use water spray, fog, or alcohol-resistant foam.
Unusual Fire/Explosion Hazards: Vapors may travel to ignition source and flash back. Container may explode in fire. Burning rate = 4.1 mm/min.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection. If possible without risk, move container from fire area. Apply cooling water to container sides until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways; dike for proper disposal.

Section 5. Reactivity Data

Stability/Polymerization: Methyl ethyl ketone is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Include chlorosulfonic acid, oleum (fuming sulfuric acid), potassium-*t*-butoxide, hydrogen peroxide + nitric acid, 2-propanol (forms explosive peroxides), chloroform + alkali, amines, ammonia, inorganic acids, caustics, copper, isocyanates, pyridines, and strong oxidizers. MEK will soften or dissolve some plastics.
Conditions to Avoid: Exposure to heat, ignition sources, and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of MEK can produce carbon dioxide gas and acrid smoke.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(183) NTP,(169) and OSHA(183) do not list methyl ethyl ketone as a carcinogen.
Summary of Risks: MEK vapors are irritating to the eyes and respiratory tract. Inhalation causes varying degrees of central nervous system depression. Approximately 75% of inhaled MEK is absorbed in humans. It is absorbed readily through the skin...

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Section 6. Health Hazard Data, *continued*

and prolonged contact may cause dermatitis. Because of its low odor threshold, MEK's irritating properties should be sufficient to prevent overexposure. MEK appears to potentiate the neurotoxic effects of some chemicals including *n*-butyl ketone and *n*-hexane, and some studies suggest that MEK may even produce neurotoxicity itself (possibly because it is partially metabolized to methanol[139]). **Medical Conditions Aggravated by Long-Term Exposure:** Dermatitis. **Target Organs:** Respiratory tract, central nervous system, skin, and eyes. **Primary Entry Routes:** Inhalation, eyes, and skin contact/absorption. **Acute Effects:** Inhalation may cause headache, dizziness, nausea, vomiting, weakness, and unconsciousness. High concentration can cause smarting in addition to irritation of the eyes and respiratory tract. In one study, exposure to 100 ppm caused slight nose and throat irritation, 200 ppm caused mild eye irritation, and 300 ppm was "objectionable" with headache and throat irritation. In another study, short exposure to 500 ppm caused nausea and vomiting. Also, workers exposed to 300 to 600 ppm for an unspecified time period experienced numbness of the fingers and arms; one worker experienced leg numbness with a tendency to "give way under him". Direct eye contact can cause painful irritation and corneal injury. **Chronic Effects:** Repeated skin contact can cause defatting and dermatitis, apparently without irritation.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water.

Inhalation: Remove exposed person to fresh air, administer 100% humidified supplemental oxygen and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of possible aspiration into the lungs.

Note to Physicians: MEK is detectable in expired air and urine. There is good correlation between urinary MEK and workplace air concentration.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against exposure. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. Dike far ahead of large spill for reclamation or disposal. For spills in water, use natural barriers or spill control booms to limit spill travel. Prevent entry into sewers, drains, and waterways. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** *Pimephales promelas* (fathead minnow LC_{50} = 3,220 mg/L/96 hr; *Lepomis macrochirus* (bluegill), TLm = 5,640 to 1,690 mg/L/24 to 96 hr. **Environmental Degradation:** In water MEK will evaporate with an expected half-life of 3 to 12 days in rivers and lakes, respectively. It slowly biodegrades in both fresh and salt water. It may degrade in ground water after a long acclimation period. It is not expected to bioconcentrate in aquatic organisms. On land, MEK will either evaporate or leach into the ground. In air, MEK will degrade by photochemical reaction with hydroxyl radicals (half-life = 2.3 days). Under smog conditions, degradation may be slightly faster. **Disposal:** Incineration is possible in permit-approved facilities. Steam stripping can be used to remove MEK from aqueous waste. Concentrations up to several wt % solvent in water can be handled with better than 99% removal expected. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): U159
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 5000 lb (2270 kg) [* per RCRA, Sec. 3001]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use any powdered air-purifying respirator with organic vapor cartridges (OVCs) or any chemical cartridge respirator with a full facepiece and OVCs. For < 3000 ppm, use any air-purifying, full facepiece respirator (gas mask) with a chin-style, front-or-back mounted organic vapor canister. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Butyl rubber and Teflon with breakthrough times (BT) of > 8 hr and polyethylene/ethylene vinyl alcohol with a BT of > 4 hr are suitable PPE materials. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) Safety **Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work and street clothes and launder before reuse. Remove MEK from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using MEK, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage/Handling Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from heat, incompatibles (Sec. 5). Periodically check containers for leaks.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all equipment used with MEK.

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the skin and respiratory system. Inform workers that MEK is absorbed through the skin and stress the importance of wearing appropriate gloves.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Methyl ethyl ketone
DOT Hazard Class: 3
ID No.: UN1193
DOT Packing Group: II
DOT Label: Flammable liquid
Special Provisions (172.102): T8

Packaging Authorizations
a) Exceptions: 173.150
b) Non-bulk Packaging: 173.202
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: —

***MSDS Collection* References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 148, 149, 153, 159, 168, 171, 183, 186
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** RE Langford, Ph.D, CIH; **Medical Review:** T Thobum, MD, MPH

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Material Safety Data Sheet Collection

Methylene Chloride **MSDS No. 310**

Date of Preparation: 11/77 Revision: G, 6/94

Section 1 - Chemical Product and Company Identification 44

Product/Chemical Name: Methylene Chloride
Chemical Formula: CH_2Cl_2
CAS No.: 75-09-2
Synonyms: DCM, dichloromethane, Freon 30, methylene bichloride, methylene dichloride, NCI-C50102, Solmethine
Derivation: Produced by chlorination of methane.
General Use: Used as a solvent for cellulose acetate, adhesives, food processing, and pharmaceuticals; in degreasing and cleaning fluids, paint and varnish removers, decaffeination of coffee, in propellant mixtures for aerosols; as a blowing agent in foams, dewaxing agent, component of fire extinguishing compound, chemical intermediate, low temperature heat-transfer medium, and as a fumigant. Formerly used as an anesthetic.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Methylene chloride, ca < 100 % vol
Trace Impurities: Stabilizers may be added such as: amines, 4-cresol, hydroquinone, methanol, 2-methyl-2-ene, 1-naphthol, nitromethane + 1,4-dioxane, phenol, resorcinol, and thymol.

OSHA PELs
8-hr TWA: 500 ppm*
Ceiling: 1000 ppm (2000 ppm 5 min. peak in any 2 hr period)

ACGIH TLV
TWA: 50 ppm (174 mg/m^3)

NIOSH REL
Carcinogen; lowest feasible concentration.

IDLH Level
Ca [5000 ppm]

DFG (Germany) MAK
TWA: 100 ppm (360 mg/m^3)
Category II: Substances with systemic effects
Onset of Effect: < 2 hr
Half-life: 2 hr to shift length

Peak Exposure Limit:
500 ppm, 30 min. average value, 2/shift

*Proposed change to: 25 ppm (TWA); 125 ppm (STEL)

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Methylene chloride is a colorless, volatile liquid with a sweet odor. It is irritating to the eyes, skin, and respiratory tract. At high concentrations it can cause narcosis (unconsciousness). Methylene chloride is metabolized to carbon monoxide in the body which contributes to much of its toxicity. It can form flammable mixtures with air (forming toxic phosgene when burned) and becomes explosive when mixed with oxygen.

Wilson Risk Scale
R 1
I 3
S 2*
K 1
*Skin absorption

HMIS
H 2*
F 1
R 0

*Chronic Effects
PPE†
†Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin and eye contact.
Target Organs: Eyes, skin, central nervous system (CNS), cardiovascular system (CVS), blood.
Acute Effects
Inhalation: Symptoms include headache, giddiness, irritability, nausea, stupor, numbness and tingling of limbs, fatigue, anemia and polymorphonuclear leukocytosis, digestive disturbances, and neurasthenic disorders (emotional and psychic disorders characterized by easy fatigue, lack of motivation, feelings of inadequacy, and psychosomatic symptoms). Many symptoms are attributed to the metabolism of methylene chloride to carbon monoxide in the body. The carbon monoxide forms carboxyhemoglobin in the blood, which unlike hemoglobin, does not have the ability to carry oxygen. This lack of oxygen leads to CNS and CVS problems. However, CNS effects *have* been seen in persons without a significantly elevated blood carbon monoxide level.
Eye: Exposure to vapors produces irritation, tearing, and conjunctivitis. Direct contact with the liquid causes severe pain, but permanent damage does not occur.
Skin: Contact is irritating and can be painful (burns) if confined to skin (i.e. trapped under gloves or clothing). Methylene chloride can be absorbed through the skin to cause systemic effects.
Ingestion: Expected to cause gastrointestinal irritation, nausea, vomiting, and systemic effects (see inhalation).
Carcinogenicity: IARC (Class 2B, possibly carcinogenic to humans with limited human and sufficient animal evidence), NTP (Class 2, reasonably anticipated to be a carcinogen with limited human and sufficient animal evidence), ACGIH (TLV-A2, suspected human carcinogen as agent is carcinogenic in animals at dose levels considered relevant to worker exposure but insufficient epidemiological studies are available to confirm an increased cancer risk), NIOSH (Class X, carcinogen defined without further categorization), EPA (Class B2, sufficient evidence from animal studies and inadequate or no data from epidemiologic studies), and DFG (MAK B, justifiably suspected of having carcinogenic potential).
Medical Conditions Aggravated by Long-Term Exposure: Skin and cardiovascular disorders.

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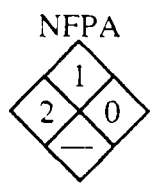
Chronic Effects: Repeated skin contact can cause dermatitis. Liver disease has been reported. *Case Reports*: 1 yr exposure caused toxic encephalopathy (toxicity of the brain) with audio and visual delusions and hallucinations; 3 yr exposure to 300 to 1000 ppm caused memory loss, intellectual impairment, and balance disturbances.
Other: Methylene chloride will cross the placenta. The estimated lethal dose is 0.5 to 5 mL/kg. Although methylene chloride has a distinct sweetish odor, it is not recognized at levels low enough to protect from overexposure.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air, administer 100% humidified, supplemental oxygen and support breathing.
Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water for at least 15 min. Consult an ophthalmologist if pain or irritation persist.
Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting with Ipecac syrup. If vomiting does not occur, the decision to perform gastric lavage should be made.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Lethal blood level = 280 mg/L. Biological monitoring: carbon monoxide in expired air (nonsmokers only). Recently, methylene chloride concentrations in urine have been found to correlate well to concentrations in air.

Section 5 - Fire-Fighting Measures



Flash Point: Methylene chloride does not have a flash point by standard tests. However, it does form flammable mixtures with air.
Autoignition Temperature: 1033 °F (556 °C)
LFL: 12% v/v
UFL: 19% v/v
LEL: 15.5% (in oxygen)
UEL: 66.4% (in oxygen)
Extinguishing Media: For small fires, use dry chemical or carbon dioxide. For large fires, use water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: Creates an explosion hazard if allowed to enter a confined space. Container may explode in heat of fire.
Hazardous Combustion Products: Hydrogen chloride, carbon monoxide and phosgene.
Fire-Fighting Instructions: Apply cooling water to sides of tanks until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.
Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel need to protect against inhalation and skin/eye contact.
Small Spills: Take up with earth, sand, vermiculite, or other absorbent, noncombustible material.
Large Spills
Containment: Dike far ahead of spill for later reclamation or disposal. Do not release into sewers or waterways.
Cleanup: Damp mop any residue.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Do not use near ignition sources. Wear appropriate PPE. Do not use plastic or rubber hose for unloading trucks or tank cars unless the materials have been tested and approved for methylene chloride service.
Storage Requirements: Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles (Sec. 10). To minimize decomposition, all storage containers should be galvanized or lined with a phenolic coating. Indoor storage tanks should have vents piped outdoors to prevent vapors from escaping into work areas. Prevent moisture from entering tanks.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Do not use closed circuit rebreathing systems employing soda lime or other carbon dioxide absorber because of formation of toxic compounds capable of producing cranial nerve paralysis. To prevent static sparks, electrically ground and bond all equipment used with and around methylene chloride.
Ventilation: Provide general or local exhaust ventilation systems to maintain airborne levels below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103)
Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on skin, liver, CNS, CVS, and blood. A complete blood count should be performed and carboxyhemoglobin levels should be determined

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periodically. Any level above 5% should prompt investigation of employee and workplace to determine the cause (smokers will already have an increased level of carboxyhemoglobin and are at increased risk). Use less hazardous solvents where possible.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use any SCBA or supplied-air respirator (with auxiliary SCBA) with a full facepiece and operated in pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Polyvinyl alcohol and Viton laminated with Neoprene are suitable materials for PPE. Natural rubber, synthetic rubbers, and polyvinyl chloride *do not* provide protection against methylene chloride. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove methylene chloride from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using methylene chloride, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Liquid

Appearance and Odor: Colorless; volatile with a sweet odor.

Odor Threshold: 205 to 307 ppm

Vapor Pressure: 350 mm Hg at 68 °F (20 °C); 440 mm Hg at 77 °F (25 °C)

Saturated Vapor Density (Air = 1.2 kg/m^3, 0.075 lb/ft^3): 2.256 kg/m^3 or 0.141 lb/ft^3

Formula Weight: 84.9

Specific Gravity (H_2O=1, at 4 °C): 1.33 at 15 °C

Water Solubility: 2%

Octanol/Water Partition Coefficient: log Kow = 1.25

Other Solubilities: Soluble in alcohol, acetone, chloroform, carbon tetrachloride, ether, and dimethylformamide.

Boiling Point: 104 °F (40 °C)

Freezing Point: -142 °F (-97 °C)

Viscosity: 0.430 cP at 68 °F (20 °C)

Refractive Index: 1.4244 at 68 °F (20 °C/D)

Surface Tension: 0.5 to 2.3 g/L (*in oxygen*)

Bulk Density: 11.07 lb/gal at 68 °F (20 °C)

Ionization Potential: 11.32 eV

Critical Temperature: 473 °F (245 °C)

Critical Pressure: 60.9 atm

Section 10 - Stability and Reactivity

Stability: Methylene chloride is stable at room temperature in closed containers under normal storage and handling conditions. Tends to carbonize when vapor contacts steel or metal chlorides at high temperatures 572 to 842 °F (300 to 450 °C).

Polymerization: Hazardous polymerization does not occur.

Chemical Incompatibilities: Include aluminum, lithium, sodium, aluminum bromide, azides, dimethyl sulfoxide + perchloric acid, N-methyl-N-nitrosourea + potassium hydroxide, sodium-potassium alloy, potassium *t*-butoxide, dinitrogen pentoxide, dinitrogen tetraoxide, nitric acid, and oxidizers. Methylene chloride will attack some forms of plastic, rubber, and coatings. Corrodes iron, some stainless steel, copper, and nickel.

Conditions to Avoid: Exposure to heat, ignition sources, and incompatibles.

Hazardous Decomposition Products: Hydrogen chloride, carbon monoxide and phosgene.

Section 11- Toxicological Information

Toxicity Data:*

Eye Effects:
Rabbit, eye: 162 mg caused moderate irritation.

Skin Effects:
Rabbit, skin: 810 mg/24 hr caused severe irritation.

Carcinogenicity:
Rat, inhalation: 3500 ppm/2 yr (intermittently) caused endocrine tumors.

Mutagenicity:
Rat, oral: 1275 mg/kg caused DNA damage.
Human, fibroblast: 5000 ppm/1 hr (continuously) caused DNA inhibition.

Acute Inhalation Effects:
Human, inhalation, TC_{Lo}: 500 ppm/1 yr (intermittently) caused altered sleep time, somnolence, and change in heart rate.
Human, inhalation, TC_{Lo}: 500 ppm/8 hr caused euphoria.

Acute Oral Effects:
Human, oral, LD_{Lo}: 357 mg/kg caused somnolence, paresthesia, and convulsions or effect on seizure threshold.
Rat, oral, LD_{50}: 1600 mg/kg

Multiple Dose Toxicity Data:
Rat, inhalation: 8400 ppm/6 hr/13 weeks (intermittently) caused changes in liver weight.

* See NIOSH, *RTECS* (PA8050000), for additional toxicity data.

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Section 12 - Ecological Information

Ecotoxicity: *Pimephales promelas* (fathead minnow), LC_{50} = 193 mg/L/96 hr; *Lepomis macrochirus* (bluegill), LC_{50} = 230 mg/L/24 hr; *Poecilia reticulata* (guppies), LC_{50} = 294 ppm/14 days. Cytotoxic to plants.

Environmental Degradation: In air, methylene chloride degrades by reaction with photochemically-produced hydroxyl radicals (half-life = a few months) but does not undergo *direct* photolysis. Degradation products include carbon monoxide, carbon dioxide, and phosgene. In water, it is removed primarily by evaporation (est. half-life = 3 to 5.6 hr under moderate mixing conditions). Some may biodegrade but it is not expected to adsorb to sediment or bioconcentrate. If released to soil most methylene chloride will rapidly evaporate. Some may leach through soil. Methylene chloride will adsorb to peat moss but not to sand.

Section 13 - Disposal Considerations

Disposal: Pour on sand or earth at a safe distance/location from occupied areas and allow to evaporate (most is transformed to carbon monoxide). A good candidate for liquid injection, rotary kiln, or fluidized bed incineration. Investigate biodegradation: methylene chloride is reported to completely biodegrade under aerobic conditions with sewage seed or activated sludge between 6 hrs. and 7 days. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Dichloromethane
Shipping Symbols: –
Hazard Class: 6.1
ID No.: UN1593
Packing Group: III
Label: Keep away from food
Special Provisions (172.102): N36, T13

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: –

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste Number (40 CFR 261.33): U080
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per RCRA, Sec. 3001 and CWA, Sec. 307(a)
CERCLA Reportable Quantity (RQ), 1000 lb (454 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 1, 8, 73, 103, 124, 132, 136, 148, 149, 153, 159, 187, 190, 192, 194, 195

Prepared By ..... M Gannon, BA
Industrial Hygiene Review ..... S Gilson, CIH
Medical Review ..... J Brent, MD, PhD

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Material Safety Data Sheets Collection:

Sheet No. 379
Tetrahydrofuran

Issued: 8/78 Revision: B, 9/92

Section 1. Material Identification

Tetrahydrofuran ($CH_2CH_2CH_2CH_2O$) Description: Derived by catalytic hydrogenation of maleic anhydride or furan (with a nickel catalyst), or by acid-catalyzed dehydration of 1,4-butanediol. To prevent peroxide formation, it is stabilized with 0.025% butylated hydroxytoluene, 0.05 to 1% *p*-cresol, 0.05 to 1% hydroquinone, or 0.01 to 1% 4,4'-thiobis (6-*t*-butyl-*m*-cresol). Used as a solvent in histological techniques or for high polymers such as polyvinyl chloride; as a reaction medium for Grignard and metal hydride reactions; for synthesis of butyrolactone, succinic acid, and 1,4-butanediol diacetate; in topcoating solutions, polymer coatings, cellophane, lacquers, magnetic tapes, and printing inks; in food packaging as long as residual amount is < 1.5% of the film; and as a Lewis base to moderate the extreme reactivity of sulfur trioxide.

R 2
I 2
S 3
K 4

NFPA

HMIS
H 2
F 3
R 2
PPE*
* Sec. 8

Other Designations: CAS No. 109-99-9, butylene oxide, cyclotetramethylene oxide, diethylene oxide, 1,4-epoxybutane, Furanidine, hydrofuran, NCI-C60560, oxacyclopentane, Oxolane, tetramethylene oxide, THF.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: THF in concentrations greater than 20% are irritating to the eyes, nose, and respiratory tract. It produces central nervous system (CNS) depression from inhalation of high concentrations. Tetrahydrofuran is highly flammable and forms explosive peroxides when uninhibited and exposed to air. Use with care!

Section 2. Ingredients and Occupational Exposure Limits

Tetrahydrofuran, ca <99%

1991 OSHA PELs
8-hr TWA: 200 ppm (590 mg/m^3)
15-min STEL: 250 ppm (735 mg/m^3)

1990 IDLH Level
20,000 ppm

1991-92 ACGIH TLVs
TWA: 200 ppm (590 mg/m^3)
STEL: 250 ppm (737 mg/m^3)

1990 DFG (Germany) MAK
Ceiling: 200 ppm (590 mg/m^3)
Category II: Substances with systemic effects
Half-life: 2 hr to shift end
Peak Exposure Limit: 1000 ppm, 30 min average value, 2/shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 25,000 ppm caused general anesthesia.
Rat, oral, LD_{50}: 2816 mg/kg; no toxic effect noted
Rat, inhalation, LC_{50}: 21,000 ppm/3 hr produced sleep, respiratory stimulation, and nausea or vomiting.

1990 NIOSH RELs
TWA: 200 ppm (590 mg/m^3)
STEL: 250 ppm (735 mg/m^3)

* See NIOSH, *RTECS* (LU5950000), for additional mutation and toxicity data.

Section 3. Physical Data

Boiling Point: 151 °F (66 °C)
Melting Point: -163 °F (-108 °C)
Relative Evaporation Rate (BuAc = 1): 8
Odor Threshold: 30 to 60 ppm
Surface Tension: 28 dyne/cm at 68 °F (20 °C)
Ionization Potential: 9.45 eV
Critical Temperature: 512.6 °F (267 °C)
Critical Pressure: 51.2 atm
Viscosity: 0.48 cP at 68 °F (20 °C)
Molecular Weight: 72.12
Density: 0.8892 at 68 °F (20/4 °C)
Water Solubility: Soluble, 30% at 77 °F (25 °C)
Other Solubilities: Soluble in alcohol, ketones, esters, ethers, and hydrocarbons.
Refraction Index: 1.4070 at 68 °F (20 °C)
Vapor Pressure: 114 mm Hg at 59 °F (15 °C); 145 mm Hg at 68 °F (20 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.096 lb/ft^3 or 1.539 kg/m^3
pH: ~ 7 (aqueous solution)
Appearance and Odor: Water-white to clear liquid with a fruity odor and pungent taste.

Section 4. Fire and Explosion Data

Flash Point: 5 °F (-15 °C) OC	Autoignition Temperature: 610 °F (321 °C)	LEL: 2% v/v	UEL: 11.8% v/v

Extinguishing Media: THF is a Class 1B Flammable Liquid. For small fires, use dry chemical, carbon dioxide, water spray, or 'alcohol-resistant' foam. For large fires, use water spray, fog, or 'alcohol-resistant' foam. **Unusual Fire or Explosion Hazards:** Vapors may travel to an ignition source and flash back. Containers may rupture in fire. Burning rate = 4.7 mm/min. Uninhibited THF forms explosive peroxides in air. Due to its volatility, even dilute THF-water mixtures present a fire hazard. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection. If fire becomes uncontrollable, evacuate for a 1500 ft radius. If possible without risk, move container from fire area or apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw and let fire burn. Withdraw from fire if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: THF forms explosive (>1%) peroxides when exposed to air or sunlight. It is inhibited (Sec. 1) to prevent peroxide formation. Hazardous polymerization may occur in the presence of cationic initiators such as strong proton acids or selected Lewis acids. **Chemical Incompatibilities:** THF will attack some forms of plastics, rubber, and coatings. It is explosive with potassium hydroxide, sodium hydroxide, and sodium tetrahydroaluminate since caustic alkalies deplete the inhibitor; reacts with potassium dioxide 2-aminophenol to form an explosive product; reacts violently with metal halides; forms explosive hydrogen gas with borane or lithium tetrahydroaluminate and reacts vigorously with bromine and calcium hydride + heat. Also incompatible with sulfinyl chloride and oxidizing materials. **Conditions to Avoid:** Exposure to heat, ignition sources, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of THF can produce carbon oxides and irritating vapors. **Other:** Because distillation or alkali treatment of stabilized THF removes the involatile antioxidant, it must be restabilized or stored under nitrogen to prevent peroxide formation. Do not store more than a few days without a stabilizer. Sodium benzophenone ketyl or an activated alumina column have been used to remove moisture and peroxides. Peroxides may also be destroyed by passage through activated carbon at 86 to 154 °F (20 to 66 °C) with contact time > 2 min. Only use lithium tetrahydroaluminate for drying THF if it is *peroxide-free* and *not* glossy wet. Distill only in presence of a reducing agent such as ferrous sulfate, since peroxide explosions have occurred.

Continue on next page

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Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[169] and OSHA[164] do not list THF as a carcinogen. **Summary of Risks:** THF is a strong skin and mucous membrane irritant when present at levels > 20% but it is not a sensitizer. Effects in humans are not well known due to a lack of exposure data. CNS depression is seen in exposure to high concentrations. Liver and kidney damage occurred in animals but recent attempts to confirm these reports have failed. Thus, the liver and kidney damage has been attributed to impurities present in the THF used in older experiments. Even so, some authorities still recommend monitoring kidney and liver function in exposed persons. **Medical Conditions Aggravated by Long-Term Exposure:** Skin diseases. **Target Organs:** Eyes, CNS, skin, respiratory system. **Primary Entry Routes:** Inhalation, skin contact. **Acute Effects:** Vapor inhalation of high concentrations can cause slight smarting of the eyes or respiratory system as well as cough and chest pain. Inhalation of 25,000 ppm can cause anesthesia which may last 6 to 8 hr. Investigators testing pharmacological properties have reported severe occipital headache, nausea, and dizziness; these are easily reversible in fresh air. A marked decrease in WBC count was observed in researchers involved in experimental spinning of synthetic fibers (made from polyvinyl chloride with THF as a solvent). Recovery occurred after 2 years treatment with cystin, liver preparate, and vitamins B & C. Alcoholic beverages appear to enhance THF toxicity. **Chronic Effects:** Possible liver and kidney damage.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air, support breathing and administer 100% humidified supplemental oxygen if needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. Gastric lavage is indicated if performed soon after ingestion or in patients at risk of convulsing.

Note to Physicians: Even though THF's effect on the liver and kidneys is uncertain, it is suggested that renal and hepatic function be monitored, especially AST, ALT, and GGT. If gastric lavage is performed protect airway by placement in Trendelenburg and left lateral decubitus position or by cuffed endotracheal intubation.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. Cleanup personnel should protect against vapor inhalation and skin/eye contact. Use water spray to reduce vapor and form nonflammable mixtures. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. Dike far ahead of large spills for later reclamation or disposal. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Blue-green algae, growth inhibition microcyctis = 225 mg/L(pH 7); Protozoa, cell multiplication inhibition test = 858 mg/L. **Environmental Degradation:** In air, THF photodegrades by reaction with hydroxyl radicals with an estimated half-life of hrs to a few days. It is soluble and expected to wash out in rain. In water, its fate is uncertain. Based on very limited evidence THF is expected to biodegrade and not absorb to sediment. Tests in distilled water showed THF to last as follows: 0.5 mg/L for 1 to 2 days, 5 mg/L for 6 to 8 days, and 10 mg/L for 10 days. **Disposal:** A good candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C), for liquid injection incineration at 1202 to 2912 °F (650 to 1600 °C), and fluidized bed incineration at 842 to 1796 °F (450 to 980 °C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U213
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311 (b)(4)]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses, chemical safety goggles, or faceshields per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For <1000 ppm, use any powered air-purifying respirator with organic vapor cartridge. For < 5000 ppm, use any supplied-air respirator (SAR) operated in continuous flow mode. For < 10,000 ppm, use any SAR or SCBA with a full facepiece. For < 20,000 ppm, use any SAR operated in pressure demand or positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber or neoprene to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in dark glass bottles or steel drums in a cool, dry, well-ventilated area away from heat, oxidizing materials and sunlight. Outside or detached storage is preferred; if inside, keep in a standard flammable liquids storage room or cabinet. Use Class 1, Group C electrical equipment. Regularly check inhibitor levels to maintain peroxide level below 1%. Before use, test for absence of peroxides with potassium iodide-starch paper. Electrically ground and bond all equipment used with THF. In addition, provide jumpers at swing joints and other necessary locations to give a ground circuit of low resistance. Restabilize and store THF that has been recovered for reuse under a blanket of dry nitrogen gas. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on the skin, eyes, CNS, and respiratory system.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Tetrahydrofuran
DOT Hazard Class: 3
ID No.: UN2056
DOT Packing Group: II
DOT Label: Flammable Liquid
Special Provisions (172.102): T8

Packaging Authorizations
a) **Exceptions:** None
b) **Non-bulk Packaging:** 173.202
c) **Bulk Packaging:** 173.242

Quantity Limitations
a) **Passenger Aircraft or Railcar:** 5 L
b) **Cargo Aircraft Only:** 60 L

Vessel Stowage Requirements
a) **Vessel Stowage:** B
b) **Other:** --

MSDS Collection **References:** 1, 73, 89, 100, 101, 103, 124, 126, 127, 132, 139, 148, 149, 153, 159, 162, 163, 164, 167, 168, 171
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD

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Material Safety Data Sheets Collection:
Sheet No. 382
Vinyl Chloride
Issued: 7/78 Revision: C, 9/92

Section 1. Material Identification

Vinyl Chloride (C_2H_3Cl) Description: Derived from ethylene dichloride and alcoholic potassium, by reaction of acetylene and hydrogen chloride (as gas or liquids), or by oxychlorination where ethylene reacts with hydrochloric acid and oxygen. Inhibitors such as butyl catechol, hydroquinone, or phenol are added to prevent polymerization. Used in the plastics industry for the production of polyvinyl chloride resins, in organic synthesis and formerly as a refrigerant, extraction solvent, and propellant (banned in 1974 because of its carcinogenic activity).

Other Designations: CAS No. 75-01-4, chloroethylene, chloroethene, ethylene monochloride, Trovidur, VC, VCM.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Vinyl chloride is a confirmed human carcinogen. Vapor inhalation leads to central nervous system (CNS) depression. The liquid can cause frostbite. It is a flammable gas at room temperature and polymerizes on exposure to air or sunlight. Avoid exposure to VC through engineering controls and wearing PPE

NFPA
R 2
I 4
S 4
K 4

HMIS
H 3*
F 4
R 2
PPE - Sec. 8
* Chronic effects

Section 2. Ingredients and Occupational Exposure Limits

Vinyl Chloride, ca 98 to 99%. Impurities include water, acetaldehyde, hydrogen chloride, hydrogen peroxide, methyl chloride, butane, 1,3-butadiene, chlorophene, diacetylene, vinyl acetylene, and propine.

1991 OSHA PELs
8-hr TWA: 1 ppm
Ceiling: 5 ppm; OSHA-X

1990 NIOSH REL
NIOSH-X

1992-93 ACGIH TLV
TWA: 5 ppm (13 mg/m³)
TLV-A1

1990 DFG (Germany) TRK*
Existing Installations: 3 ppm
MAK-A1

1985-86 Toxicity Data†
Man, inhalation, TC_{Lo}: Intermittent exposure to 200 ppm for 14 yr caused liver tumors.
Man, inhalation, TC_{Lo}: 30 mg/m³/5 yr caused spermatogenesis.
Human, inhalation, TC: Continuous exposure to 300 mg/m³ for an undetermined number of weeks caused blood tumors.
Rat, oral, LD_{50}: 500 mg/kg; toxic effects not yet reviewed

* TRK (technical exposure limit) is used in place of MAK when a material is a carcinogen. Unlike an MAK below which no adverse effects are expected, the TRK is a limit set below which adverse effects may still occur. This is based on the theory that 1 molecule of a carcinogenic substance may still produce a tumor. The TRK is set to allow for an acceptable risk (for example, 1 tumor in 1 million persons may be an acceptable risk).
† See NIOSH, *RTECS* (KU9625000), for additional mutation, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 7 °F (-13.9 °C)
Freezing Point: -245 °F (-159.7 °C)
Molecular Weight: 62.5
Specific Gravity: 0.9106 at 68 °F (20 °C)
Ionization Potential: 9.99 eV
Refraction Index: 1.370 at 20 °C/D
Surface Tension: 23.1 dyne/cm at -4 °F (-20 °C)
Odor Threshold: 2000 to 5000 ppm*
Vapor Density (Air = 1): 2.155

Water Solubility: Slightly soluble, 0.1% at 77 °F (25 °C)
Other Solubilities: alcohol, benzene, carbon tetrachloride, ether, hydrocarbon and oils.
Vapor Pressure: 2530 mm Hg at 68 °F (20 °C), 400 mm Hg at -18.4 °F (-28 °C)
Critical Temperature: 304.7 °F (151.5 °C)
Critical Pressure: 56.8 atm
Viscosity: 0.01072 cP at 68 °F (20 °C), *gas*; 0.28 cP at -4 °F (-20 °C), *liquid*
Appearance and Odor: A gas at room temperature. Usually found as a compressed/cooled liquid. The colorless liquid forms a vapor with a pleasant ethereal odor.

*The actual vapor concentration that can be detected by humans has not been adequately determined and varies from one individual to another, from impurities, and probably from exposure duration. The odor threshold is not an accurate warning of exposure.

Section 4. Fire and Explosion Data

Flash Point: -108.4 °F (-78 °C) OC	Autoignition Temperature: 882 °F (472 °C)	LEL: 3.6% v/v	UEL: 33% v/v

Extinguishing Media: For small fires, use dry chemical or carbon dioxide. For large fires, use water spray, fog, or regular foam. **Unusual Fire or Explosion Hazards:** Large fires can be practically inextinguishable. Vapors may travel to an ignition source and flash back. VC may polymerize in cylinders or tank cars and explode in heat of fire. Vapors pose an explosion hazard indoors, outdoors, and in sewers. VC decomposes in fire to hydrogen chloride, carbon monoxide, carbon dioxide, and phosgene. Burning rate = 4.3 mm/min. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Stop gas leak if possible. Let tank, tank car, or tank truck burn unless leak can be stopped. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if this is impossible, withdraw from area and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. *Do not* release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Long term exposure to air may result in formation of peroxides which initiates explosive polymerization of the chloride. VC can polymerize on exposure to light or in presence of a catalyst. **Chemical Incompatibilities:** VC can explode on contact with oxide of nitrogen, may liberate hydrogen chloride on exposure to strong alkalies, and is incompatible with copper, oxidizers, aluminum, and peroxides. In the presence of moisture, VC attacks iron and steel. **Conditions to Avoid:** Exposure to sunlight, air, heat, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of vinyl chloride can produce carbon oxides, and chloride gas.

Section 6. Health Hazard Data

Carcinogenicity: Vinyl chloride is listed as a carcinogen by the IARC (Class 1, *sufficient human evidence*),[164] NTP (Class 1, *sufficient human evidence*),[169] NIOSH (Class X, *carcinogen defined without further categorization*),[163] ACGIH (TLV-A1, *confirmed human carcinogen*),[163] DFG (MAK-A1, *capable of inducing malignant tumors in humans*),[163] and OSHA (Class X, *carcinogen defined without further categorization*).[164] Liver tumors (angiosarcomas) are confirmed from VC exposure. Other tumors of the CNS, respiratory system, blood, and lymphatic system have occurred from exposure to the polyvinyl chloride manufacture process but VC itself may not be the causative agent. **Summary of Risks:** Vapor inhalation causes varying degrees of CNS depression with noticeable anesthetic effects at levels of 1% (10,000 ppm). Studies have shown loss of libido and sperm in men exposed to VC and in Russian studies, 77% of exposed women experienced ovarian dysfunction, benign uterine growths, and prolapsed genital organs. However, no teratogenic effects have been seen in offspring of exposed workers.

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Section 6. Health Hazard Data, *continued*

It appears that metabolism is necessary before many of VC's toxic effects occur. Some vinyl chloride is exhaled unchanged but most is metabolized to chloroacetaldehyde. Skin absorption may occur if liquid is confined on skin but absorbed amount would be small. It is possible that the phenol inhibitor may be absorbed as well. The compressed liquid can cause frostbite. Vapors are severely irritating to the eyes. Chronic exposure can cause cancer and a triad of syndromes known as *vinyl chloride disease.* **Medical Conditions Aggravated by Long-Term Exposure:** Liver, cardiac, pulmonary, and connective tissue disorders. **Target Organs:** Liver, CNS, respiratory and lymphatic systems, bone, and connective tissue of the skin. **Primary Entry Routes:** Inhalation, skin/eye contact. **Acute Effects:** CNS effects include fatigue, headache, vertigo, ataxia, euphoria, visual disturbances, dulling of auditory cues, numbness and tingling in the extremities, narcosis, unconsciousness, and death due to respiratory failure. Respiratory problems include dyspnea, asthma, and pneumonoconiosis. **Chronic Effects:** Repeated exposure has lead to liver cancer; confirmed because of the otherwise rarity of its type (angiosarcoma). Tumors in other organs have occurred in the polyvinyl chloride industry but agents other than VC may be responsible; authorities are still debating this issue. A triad of other effects are associated with VC exposure. Acro-osteolysis is associated with hand cleaning of polymerization vessels and characterized by dissolution of bone in the hands, especially when associated with resorption. Raynaud's Phenomenon is a vascular disorder marked by recurrent spasm of the capillaries and especially those of the fingers and toes on exposure to cold. This is usually accompanied by pain and in severe cases may progress to local gangrene. Sclerodermatous skin changes (affecting the dorsal hands and distal forearms) are seen and described as a slowly progressive disease marked by deposition of fibrous connective tissue in the skin. The skin becomes thickened and raised nodules appear. Arthralgias (pain in one or more joints) and blood changes with decreased platelet number and capillary abnormalities may also occur.
FIRST AID Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. For frostbite, immerse affected area in 107.6 °F (42 °C) water until completely rewarmed. *Do not* use dry heat. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Unlikely! VC is a gas above 7 °F (-14°C). **Note to Physicians:** Endotracheal intubation may be required if significant CNS or respiratory depression occur. Diagnostic test: thiodiglycolic acid in urine (normally < 2 mg/g creatinine).

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. If possible without risk, stop gas flow. Shut off ignition sources. Report any release > 1 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** VC reacts with hydroxyl radicals in the trophosphere with a half-life of 1.2 days. The half-life = a few hr in photochemical smog. Reaction products in the air include chloroacetaldehyde, hydrogen chloride, chloroethylene, epoxide, formaldehyde, formyl chloride, formic acid, and carbon monoxide. In soil, VC rapidly volatilizes. What does not evaporate will be highly mobile and may leach into groundwater. In water, VC is not expected to hydrolyze, bioconcentrate, or absorb to sediment. It will rapidly volatilize with an estimated half-life of 0.805 hr for evaporation from a river 1 meter deep with a current of 3 meter/sec and a wind velocity of 3 meter/sec. In waters containing photosensitizers such as humic acid, photodegradation will be rapid. **Soil Absorption/Mobility:** From an estimated solubility of 2,700 ppm, a Koc of 56 is established for VC which indicates high soil mobility and potential to leach into groundwater. **Disposal:** Dilute any waste compressed liquid to a 1% solution and remove phenol inhibitor as sodium. Pour onto vermiculite, sodium bicarbonate, or a sand & soda ash mixture (90/10). Add slaked lime if fluoride is present. Mix in paper boxes, place in incinerator, cover with scrap wood and paper, and ignite with excelsior train. Another method is to dissolve waste in a flammable solvent and spray in incinerator firebox equipped with an afterburner and alkali scrubber. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U043
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1 lb (0.454 kg) [* per CWA, Sec. 307 (a); CAA, Sec. 112, & RCRA, Sec. 3001]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. According to NIOSH[148], for any detectable concentration use a SCBA or supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode. See 29 CFR 1910.1017 for detailed OSHA respirator recommendations. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of Viton or chlorinated polyethylene to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL's (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate work clothes from street clothes, launder before reuse and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area in clearly labeled containers. Outside or detached storage is preferred. Large amounts should be stored in steel containers under pressure. Keep separate from incompatibles (Sec. 5). Venting, under pressure should be safety relief. At atm, venting should be pressure vacuum. Regularly monitor inhibitor levels. To avoid static sparks, electrically ground and bond all equipment used with VC. Avoid open flames, spark formation and electric discharges around VC. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Install Class 1, Group D electrical equipment. **Administrative Controls:** Inform VC exposed personnel of hazards associated with its use. Preplacement and periodic medical exams of workers exposed above the action level is mandatory under OSHA 29 CFR (1910.1017). Monitor for liver cancer, scleroderma, pneumonitis, clotting abnormalities, and acro-osteolysis.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Vinyl Chloride
DOT Hazard Class: 2.1
ID No.: UN1086
DOT Packing Group: --
DOT Label: Flammable Gas
Special Provisions (172.102): B44

Packaging Authorizations
a) Exceptions: 173.306
b) Non-bulk Packaging: 173.304
c) Bulk Packaging: 173.314 & 173.315

Quantity Limitations
a) Passenger Aircraft or Railcar: Forbidden
b) Cargo Aircraft Only: 150 kg

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168, 171, 174, 175
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD

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Material Safety Data Sheets Collection:
Sheet No. 385
Ethylbenzene
Issued: 8/78 Revision: B, 9/92

Section 1. Material Identification

Ethylbenzene ($C_6H_5C_2H_5$) Description: Derived by heating benzene and ethylene in presence of aluminum chloride with subsequent distillation, by fractionation directly from the mixed xylene stream in petroleum refining, or dehydrogenation of naphthenes. Used as a solvent, an antiknock agent in gasoline; and as an intermediate in production of synthetic rubber, styrene, cellulose acetate, diethylbenzene, acetophenone, ethyl anthraquinone, propyl oxide, and α-methylbenzol alcohol.
Other Designations: CAS No. 100-41-4, ethylbenzol, EB, phenylethane, NCI-C56393.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I 3
S 2*
K 4
* Skin absorption

NFPA

HMIS
H 2†
F 3
R 0
PPE - Sec. 8
† Chronic effects

Cautions: Ethylbenzene is a skin and mucous membrane irritant considered the most irritating of the benzene series. Inhalation causes acute and chronic central nervous system (CNS) effects. It is highly flammable and forms explosive mixtures with air.

Section 2. Ingredients and Occupational Exposure Limits

Ethylbenzene, ca >99.0%. Impurities include ~ 0.1% *meta* & *para* xylene, ~ 0.1% cumene, and ~ 0.1% toluene.

1991 OSHA PELs
8-hr TWA: 100 ppm (435 mg/m^3)
15-min STEL: 125 ppm (545 mg/m^3)
Action Level: 50 ppm (217 mg/m^3)

1990 IDLH Level
2000 ppm

1990 NIOSH REL
TWA: 100 ppm (435 mg/m^3)
STEL: 125 ppm (545 mg/m^3)

1992-93 ACGIH TLVs
TWA: 100 ppm (434 mg/m^3)
STEL: 125 ppm (545 mg/m^3)

1990 DFG (Germany) MAK
TWA: 100 ppm (440 mg/m^3)
Category 1: local irritants
Peak Exposure Limit: 200 ppm, 5 min momentary value, max of 8/shift
Danger of cutaneous absorption

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 100 ppm/8 hr caused eye effects, sleep, and respiratory changes.
Human, lymphocyte: 1 mmol/L induced sister chromatid exchange.
Rat, oral, LD_{50}: 3500 mg/kg; toxic effects not yet reviewed
Rat (female), inhalation, TC_{Lo}: 1000 ppm/7 hr/day, 5 days/wk, for 3 wk prior to mating and daily for 19 days of gestation produced pups with high incidence of extra ribs.(179)

* See NIOSH, *RTECS* (DA0700000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 277 °F (136 °C)
Melting Point: -139 °F (-95 °C)
Surface Tension: 31.5 dyne/cm
Ionization Potential: 8.76 eV
Viscosity: 0.64 cP at 77 °F (25 °C)
Refraction Index: 1.4959 at 68 °F (20 °C)
Relative Evaporation Rate (ether = 1): 0.0106
Bulk Density: 7.21 lb/Gal at 77 °F (25 °C)
Critical Temperature: 651 °F (343.9 °C)
Critical Pressure: 35.6 atm
Molecular Weight: 106.16
Density: 0.863 at 77 °F (25 °C)
Water Solubility: Slightly, 14 mg/100 mL at 59 °F (15 °C)
Other Solubilities: Miscible in alcohol, ether; soluble in carbon tetrachloride, benzene, sulfur dioxide, and many organic solvents; insoluble in ammonia
Odor Threshold: 2.3 ppm
Vapor Pressure: 7.1 mm Hg at 68 °F (20 °C); 10 mmHg at 78.62 °F (25.9 °C); 100 mm Hg 165.38 °F (74.1 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.0768 lb/ft^3 or 1.2298 kg/m^3

Appearance and Odor: Colorless, flammable liquid with a pungent odor.

Section 4. Fire and Explosion Data

Flash Point: 64 °F (18 °C) CC	Autoignition Temperature: 810 °F (432 °C)	LEL: 1.0% v/v	UEL: 6.7% v/v

Extinguishing Media: Class 1B Flammable liquid. For small fires, use dry chemical, carbon dioxide, or 'alcohol-resistant' foam. For large fires, use fog or 'alcohol-resistant' foam. Use water only if other agents are unavailable; EB floats on water and may travel to an ignition source and spread fire. **Unusual Fire or Explosion Hazards:** Burning rate = 5.8 mm/min. Vapors may travel to an ignition source and flash back. Container may explode in heat of fire. EB poses a vapor explosion hazard indoors, outdoors, and in sewers. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Cool container sides with water until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Withdraw immediately if you hear rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Ethylbenzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Reacts vigorously with oxidizers.
Conditions to Avoid: Exposure to heat and oxidizers.
Hazardous Products of Decomposition: Thermal oxidative decomposition of EB can produce acrid smoke and irritating fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list EB as a carcinogen. **Summary of Risks:** Occupational exposure to EB alone is rare since it is usually present together with other solvents. EB is irritating to the eyes, skin, and respiratory tract. Vapor inhalation produces varying degrees of CNS effects depending on concentration. The liquid is absorbed through the skin but vapors are not. 56 to 64% of inhaled ethylbenzene is retained and metabolized. Urinary metabolites following exposure to 23 to 85 ppm for 8 hr are mandelic acid (64%), phenylglyoxylic acid (25%), and methylphenylcarbinol/1-phenyl ethanol (5%). Concurrent exposure to xylene and ethylbenzene causes slower excretion of EB metabolites. Based on the rat LD_{50}, one manufacturer gives 3 to 4 oz. as the lethal dose for a 100 lb person.

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Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Skin and CNS diseases and impaired pulmonary function (especially obstructive airway disease). **Target Organs:** Eyes, respiratory system, skin, CNS, blood. **Primary Entry Routes:** Inhalation, skin and eye contact. **Acute Effects:** Vapor inhalation of 200 ppm caused transient eye irritation; 1000 ppm caused eye irritation with profuse watering (tolerance developed rapidly); 2000 ppm caused severe and immediate eye irritation and watering, nasal irritation, chest constriction, and vertigo; 5000 ppm was intolerable and caused eye and nose irritation. Inhalation of high concentrations may cause narcosis, cramps, and death due to respiratory paralysis. Skin exposed to pure ethylbenzene for 10 to 15 min absorbed 22 to 33 mg/cm^2/hr. Immersion of hand in solutions of 112 & 156 mg/L for 1 hr absorbed 118 & 215.7 µg/cm^2/hr, respectively. **Chronic Effects:** Repeated skin contact may cause dryness, scaling, and fissuring. Workers chronically exposed to > 100 ppm complained of fatigue, sleepiness, headache, and mild irritation of the eyes and respiratory tract. Repeated vapor inhalation may result in blood disorders, particularly leukopenia (abnormally low level of white blood cells) and lymphocytosis.

FIRST AID

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting! Aspiration of even a small amount of EB in vomitus can cause severe damage since its low viscosity and surface tension will cause it to spread over a large area of the lung tissue.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: BEI = mandelic acid in urine (1.5 g/g of creatinine), sample at end of shift at workweeks end. Since this test is not specific, test for EB in expired air for confirmation.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel. Isolate and ventilate area, deny entry and stay upwind. Shut off all ignition sources. Cleanup personnel should protect against vapor inhalation and skin/eye contact. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container. Dike far ahead of large spill for later reclamation or disposal. Report any release >1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to soil, EB partially evaporates into the atmosphere, with a half-life of hrs to wks, and some leaches into groundwater, especially in soil with low organic carbon content. Biodegradation occurs with a half-life of 2 days. Some EB may absorb to sediment or bioconcentrate in fish. Evidence points to slow biodegradation in groundwater. In air, it reacts with photochemically produced hydroxyl radicals with a half-life of hrs to 2 days. Additional amounts may be removed by rain. **Ecotoxicity Values:** Shrimp (*Mysidopsis bahia*), LC_{50} = 87.6 mg/L/96 hr; sheepshead minnow (*Cyprinodon variegatus*) LC_{50} = 275 mg/L/96 hr; fathead minnow (*Pimephales promelas*) LC_{50} = 42.3 mg/L/96 hr in hard water & 48.5 mg/L/96 hr in softwater. **Disposal:** A candidate for rotary kiln incineration at 1508 to 2912°F (820 to 1600°C), liquid injection incineration at 1202 to 2912°F (650 to 1600°C), and fluidized bed incineration at 842 to 1796°F (450 to 980°C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.21): No. D001
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311 (b)(4) & CWA, Sec. 307 (a)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use a powered air-purifying respirator with an appropriate organic vapor cartridge, a supplied-air respirator (SAR), SCBA, or chemical cartridge respirator with appropriate organic vapor cartridge. For < 2000 ppm, use a SAR or SCBA with a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of Viton or polyvinylchloride to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area away from ignition sources and oxidizers. Outside or detatched storage is preferred. If inside, store in a standard flammable liquids cabinet. Containers should have flame-arrester or pressure-vacuum venting. To prevent static sparks, electrically ground and bond all equipment used with ethylbenzene. Install Class 1, Group D electrical equipment. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain levels as low as possible. Purge and ventilate reaction vessels before workers are allowed to enter for maintenance or cleanup. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, skin, blood, and respiratory system.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Ethylbenzene
DOT Hazard Class: 3
ID No.: UN1175
DOT Packing Group: II
DOT Label: Flammable liquid
Special Provisions (172.102): T1

Packaging Authorizations
a) Exceptions: 173.150
b) Non-bulk Packaging: 173.202
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60 L

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: —

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 153, 159, 162, 163, 164, 167, 168, 171, 176, 179
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheet

From Genium's Reference Collection
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GENIUM PUBLISHING CORP.

No. 395
CUMENE
(Revision A)

Issued: September 1978
Revised: February 1987

SECTION 1. MATERIAL IDENTIFICATION

22

MATERIAL NAME: CUMENE

DESCRIPTION/USES: An aromatic hydrocarbon. Used as a solvent and in the production of phenol, acetone, and alpha methylstyrene.

OTHER DESIGNATIONS: Cumol, 1-Methylethylbenzene, Isopropylbenzene, 2-Phenylpropane, $C_6H_5C_3H_7$, $C_6H_5CH(CH_3)_2$, CAS #0098-82-8

MANUFACTURER: Material is available from many suppliers, including: Aldrich Chemical Co., PO Box 355, Milwaukee, WI 53201; Telephone: (414) 273-3850

HMIS

H	2		
F	3	R	1
R	0	I	3
PPE*		S	2
*See Sect. 8		K	4

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Cumene, CAS #0098-82-8	ca 99	8-hr TWA 50 ppm (Skin)* or 245 mg/m^3 Mouse, Inhalation, LC_{50}: 2040 ppm/7 hrs Rat, Oral, LD_{50}: 1400 mg/kg Rat, Inhalation, LC_{50}: 8000 ppm/4 hrs
*Current OSHA PEL and ACGIH (1986-87) TLV.		

SECTION 3. PHYSICAL DATA

Boiling Point at 1 atm ... 305.6°F (152°C)
Vapor Pressure (mm Hg) at 20°C ... 8
Vapor Density (Air=1) ... 4.1
Water Solubility at 20°C, wt. % ... <0.01
Soluble in Alcohol
Volatiles, % ... ca 100

Specific Gravity, 20/4°C ... 0.864
Evaporation Rate (BuAc=1) ... Very Low
Melting Point ... -140.8°F (-96°C)
Molecular Weight ... 120.2

Appearance and odor: A clear, colorless liquid; sharp aromatic odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
64.8-111.2°F (36-44°C), CC	797°F (425°C)	Vol %	0.9	6.5

EXTINGUISHING MEDIA: Carbon dioxide, dry chemical, or foam. A water spray may be insufficient in putting out a cumene fire, but use it to cool containers that have been exposed to fire to prevent their rupture. Use of a water stream on the burning liquid can scatter flames.

Cumene is an OSHA Class IC or Class II combustible liquid (depending on the actual flash point). It is a fire and explosion hazard while heated. Its heavier-than-air vapors can flow along surfaces to distant sources and then flash back.

Fire fighters should use self-contained breathing apparatus.

SECTION 5. REACTIVITY DATA

Cumene is stable. Hazardous polymerization cannot occur.

This material is incompatible with oxidizing agents. Avoid exposing it to sources of heat and ignition.

Hazardous products of decomposition may include carbon monoxide.

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SECTION 6. HEALTH HAZARD INFORMATION

Cumene is not listed as a carcinogen by the NTP, IARC, or OSHA.
Excessive inhalation exposure to cumene vapors irritates the eyes and the mucous membranes of the upper respiratory tract and can cause headache, narcosis, and unconsciousness, depending on the level of concentration and the time of exposure. Systemic effects can have a relatively long duration after overexposure. Chronic exposure of rats to cumene at concentrations above 500 ppm causes congestion of the lungs, kidneys, and liver. Contact of this liquid with the eyes or skin can be irritating. Repeated or prolonged contact is defatting to the skin and can produce dermatitis. Absorption occurs through the skin. Ingestion can be moderately to severely toxic. Experiments where mice were subjected to doses of cumene (LC_{50}: 2040 ppm) indicate resulting central nervous system depression.

TARGET ORGANS: Eyes, upper respiratory tract, skin, central nervous system. PRIMARY ENTRY: Inhalation, skin absorption. ACUTE EFFECTS: Irritation of eyes and skin. Possible dizziness and drowsiness. CHRONIC EFFECTS: Dermatitis.

FIRST AID: EYE CONTACT: Flush eyes thoroughly, including under eyelids, with running water for 15 minutes. Get medical help.* SKIN CONTACT: Remove contaminated clothing. Flush affected area with water; wash with soap and water. Get medical help.* INHALATION: Remove victim to fresh air. Restore and/or support his breathing as required. Get medical help.* INGESTION: Never give anything by mouth to someone who is unconscious or convulsing. Get medical help.*

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Before using cumene it is essential that proper emergency procedures be established and made known to all personnel involved with it.
Notify safety personnel of cumene spill or leak and implement containment procedures. Remove source of heat or ignition. Provide optimum explosion-proof ventilation. Cleanup personnel should use protection against inhalation of vapors/mist and contact with liquid. Shut off leaks if you can do so without risk. Small spills can be absorbed with vermiculite or sand. Using a nonsparking scoop, place waste in an appropriate container for disposal. Prevent runoff from entering a sewer, confined areas, or surface waters.
Waste may be burned in an approved incinerator.

EPA, Clean Water Act, Reportable Spill Quantity: Not Listed.

SECTION 8. SPECIAL PROTECTION INFORMATION

Wear chemical safety goggles and/or full facepiece where splashing can occur. Wear impervious gloves, apron, boots, and other protective clothing suitable to use conditions to prevent repeated or prolonged skin contact with cumene. Use respirator protection approved by NIOSH for nonroutine and emergency situations to prevent overexposure. Use an organic-cartridge respirator for exposures below 1000 ppm (full face protection is required above 500 ppm). Self-contained or air-supplied breathing equipment should be available for use above 1000 ppm or for unknown concentrations. Special attention to inhalation hazards is required when cumene is heated or misted. Provide general and local explosion-proof exhaust ventilation to meet TLV requirements. Use properly designed hoods that maintain a minimum of 100 lfm (linear feet per minute) face velocity. Nonimpervious clothing contaminated with cumene should be removed promptly and not worn again until laundered.

Eyewash stations and washing facilities should be available to areas of use and handling.

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

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store cumene in a closed container in a cool, dry, well-ventilated area away from sources of heat. Protect containers from physical damage and sources of ignition.
Ground and bond metal containers for transfers of liquid. Use nonsparking tools.
Where concentrations of cumene can exceed 2200 ppm (25% of LEL), ductwork casing and exhaust fan elements should be nonsparking and installed in such a way that would prevent contact between the casing and fan blades.
Avoid breathing cumene vapors. Minimize skin contact by wearing proper gloves and suitable work clothing. Practice good personal hygiene. Wash thoroughly after handling. Do not eat cumene.

Cumene is not designated as a hazardous substance by the EPA (40 CFR 116).
DOT Classification: Combustible Liquid DOT No. UN1918

Data Source(s) Code: 1, 4-9, 12, 14, 16, 31, 38, 47, 59, 82, 84. CK

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Approvals	
Indust. Hygiene/Safety	4/87
Medical Review	

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Material Safety Data Sheets Collection:
Sheet No. 397
n-Hexane
Issued: 10/78 Revision: D, 9/92

Section 1. Material Identification

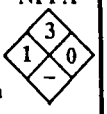
n-Hexane ($CH_3(CH_2)_4CH_3$) **Description:** Derived by fractional distillation from petroleum (molecular sieve process). Used as a solvent for glues, cements, adhesives, fats, and oils; a lab reagent; liquid in low temperature thermometers (instead of mercury); thinner, cleaning agent; polymerization reaction medium; an alcohol denaturant; in retreading tires for determining the refraction index of minerals.

Other Designations: CAS No. 110-54-3, dipropyl, Gettysolve-B, hexyl hydride, NCI-C60571, Skellysolve-B.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I 3
S 2*
K 3
* Skin absorption

NFPA



HMIS
H 2†
F 3
R 0
PPE-Sec. 8
† Chronic effects

Cautions: *n*-Hexane is highly flammable. It is irritating to the eyes, skin, and mucous membranes. Vapor inhalation produces central nervous system (CNS) depression, becoming anesthetic at high concentrations. Chronic exposure may result in polyneuropathy.

Section 2. Ingredients and Occupational Exposure Limits

n-Hexane; commercial hexane is a mixture of *n*-hexane and isomers of methyl pentane and heptane. 1 to 6% benzene may also be present.

1991 OSHA PEL
8-hr TWA: 50 ppm (180 mg/m^3)

1990 IDLH Level
5000 ppm

1990 NIOSH REL
TWA: 50 ppm (180 mg/m^3)

1992-93 ACGIH TLV
TWA: 50 ppm (176 mg/m^3)

1990 DFG (Germany) MAK
TWA: 50 ppm (180 mg/m^3)
Category II: substances with systemic effects
Half-life: < 2 hr
Peak Exposure Limit: 100 ppm, 30 min average value, 4/shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 5000 ppm/10 min caused hallucinations and distorted perceptions.
Rat, oral, LD_{50}: 28,710 mg/kg; no toxic effect noted
Rat, inhalation, TC_{Lo}: 1000 ppm/6 hr from the 8th to 16th day of pregnancy produced effects on newborn growth.
Rabbit, eye: 10 mg caused mild irritation.

* See NIOSH, *RTECS* (MN9275000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 156 °F (69 °C)
Freezing Point: -139 °F (-95 °C)
Vapor Pressure: 150 mm Hg at 77 °F (25 °C)
Refraction Index: 1.37486 at 68 °F (20 °C)
Critical Temperature: 453.2 °F (234 °C)
Critical Pressure: 29.7 atm
Liquid Surface Tension: 18.4 dyne/cm
Odor Threshold: 65 ppm

Molecular Weight: 86.17
Density: 0.66 at 20/4 °C
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.1049 lb/ft^3 or 1.678 kg/m^3
Water Solubility: Slightly, 0.014 mg/ml at 68 °F (20 °C)
Other Solubilities: Alcohol, acetone, chloroform, ether, and most non-polar solvents.
Ionization Potential: 10.18 eV
Viscosity: 0.334 cP at 35 °F (2 °C), 0.306 cP at 80 °F (27 °C), 0.276 cP at 145 °F (62.5 °C)
Appearance and Odor: A colorless, volatile liquid with a gasoline-like odor.

Section 4. Fire and Explosion Data

Flash Point: -7.6 °F (-22 °C)	Autoignition Temperature: 437 °F (225 °C)	LEL: 1.2% v/v	UEL: 7.5% v/v

Extinguishing Media: *n*-Hexane is a Class 1B Flammable Liquid. For small fires, use dry chemical, carbon dioxide, water spray, or regular foam. For large fires, use water spray, fog, or regular foam. **Unusual Fire or Explosion Hazards:** Vapors may travel to an ignition source and flash back. Container may explode in heat of fire. *n*-Hexane poses a vapor explosion hazard indoors, outdoors, and in sewers. Burning rate = 7.3 mm/min. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing appar-atus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection. If possible without risk, move container from fire area. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from fire and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Discoloration may indicate danger of BLEVE (boiling liquid expanding vapor explosion). Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: *n*-Hexane is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Incompatible with strong oxidizers and may explode at 82.4 °F (28 °C) when mixed with dinitrogen tetraoxide. **Conditions to Avoid:** Contact with heat and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of *n*-hexane can produce acrid smoke and irritating vapors.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list *n*-hexane as a carcinogen. Although there is no data on human carcinogenicity specifically caused by n-hexane, there is an increase in association between Leukemia risk in the rubber industry and exposure to a variety of substances including hexane. **Summary of Risks:** Vapors are irritating to the skin, eyes, and respiratory tract. Inhalation produces varying degrees of CNS depression depending on concentration. High concentrations may lead to asphyxia (oxygen displacement). Chronic exposure (usually at least 60 to 240 ppm) results in neurotoxicity characterized by sensory loss, pain, and neurogenic atrophy of skeletal muscle. Peripheral neuropathy is mostly of the 'stocking & glove' type. *n*-Hexane is ultimately converted to 2,5-hexanedione during metabolism and is considered to be the metabolite responsible for toxicity. Evidence exists that *n*-hexane accumulates in fatty tissue which would explain its affinity for the blood, liver, and brain where lipids are prevalent. After exposure has ceased, the half-life is 64 hrs. Metabolism is inhibited by co-exposure to toluene, methylethyl ketone, or methyl *n*-butyl ketone. *n*-Hexane is absorbed through the skin in both liquid and vapor form. Therefore, dermal vapor absorption raises biological levels above those reached during inhalation of or below the TLV concentration. This is why it is imperative that protective clothing be used so that the TLV levels are sufficient to prevent over-exposure. **Medical Conditions Aggravated by Long-Term Exposure:** Skin, CNS, PNS, and respiratory diseases. **Target Organs:** Eyes, skin, respiratory system, central and peripheral nervous system. **Primary Entry Routes:** Inhalation, skin contact/absorption, eyes, ingestion. **Acute Effects:** Vapor inhalation produced marked vertigo and hallucinations at 5000 ppm/10 min; drowsiness, fatigue, appetite loss, and paresthesia in the distal extremities at 1000 to 2500/12 hrs; muscle weakness, cold pulsation in extremeties, blurred vision, headache, anorexia and onset of polyneuropathy at 500 to 2500 ppm (time not given).

Continue on next page

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Section 6. Health Hazard Data

Skin contact causes immediate irritation with redness, painful burning and possible blisters. Eye contact produces irritation, watering, and burning. Ingestion poses a serious aspiration hazard. If aspiration into the lungs occurs, asphyxiation from oxygen displacement may lead to brain damage and cardiac arrest. Cardiac sensitization to epinephrine (the body's adrenalin) may cause rhythm disturbances with potentially fatal consequences. **Chronic Effects:** Polyneuropathy occurs from repeated exposure to levels typically in the 400 to 600 ppm range; there is a case of polyneuropathy after exposure to 54 to 200 ppm/1 year. Initial symptoms include muscle weakness, motor loss, sensation disturbances (numbness and pain without stimulus), and distal symmetric leg pain after 2 to 6 months exposure. Clinical studies indicate muscle atrophy (wasting away), foot drop, decreased muscle tone and strength, and paresthesias of the arms and legs. Vision problems including changes in color vision, retinal pigmentation, and in perifoveal capillaries were found in workers exposed to 420 to 1280 ppm for > 5 years. Progression of neuropathy may continue for several months after exposure has ceased, followed by slow recovery taking on the average of 9 to 10 months and rarely, up to 2 years. Residual spinal cord damage was noted in most severely injured victims.

FIRST AID ***Emergency personnel should protect against exposure***

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and administer supplemental oxygen as needed. Intubation may be necessary in severe cases (aspiration of liquid). **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of severe aspiration hazard. If spontaneous vomiting occurs, position head to avoid aspiration of vomitus.

Note to Physicians: BEI = 2,5-hexanedione in urine, sample at end of shift at workweeks end, 5 mg/g creatine. Also measure *n*-hexane in expired air. Analgesics may be necessary for pain management, there is no specific antidote. Monitor arterial blood gases in cases of severe aspiration.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against vapor inhalation and skin/eye contact. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. Dike far ahead of large spill for later disposal or reclamation. For water spills, use oil skimming equipment to lift spill. Absorbent foams can be applied to slick. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Degradation:** If released on soil, *n*-hexane will readily volatilize from moist surfaces although some may absorb to soil. In water, *n*-hexane will volatilize rapidly although some will absorb to sediment. The log bioconcentration factor (log BCF) estimated at 2.24 to 2.89 suggests bioconcentration is not an important factor in aquatic systems. The estimated Koc of 1250 to 4100 indicates that *n*-hexane absorbs to carbon/organic matter. Volatilization half-life from a model river is 2.7 hr at 77 °F (25 °C), 1 meter deep flowing at 1m/sec with a 3 m/sec wind speed. Volatilization from a model pond (which considers effect of absorption) is estimated at 6.8 days. In the atmosphere, it is expected to exist entirely in the vapor phase. It does not absorb UV light in the environmentally significant range (> 290 nm). It reacts with photochemically produced hydroxyl radicals. Estimated lifetime under photochemical smog conditions is 5.9 hr (SE England). **Disposal:** Spray into an incinerator (may burn quicker by addition of another flammable solvent). Evaporation in a suitable hood may be used for smaller amounts. Landfill is *not* recommended. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
Listed as a RCRA Hazardous Waste (40 CFR 261.21): D001, *Characteristic of ignitability*
Listed as 'Unlisted hazardous Waste, *Characteristic of ignitability*' a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 500 ppm, use a supplied-air respirator (SAR) or SCBA. For < 1250 ppm, use a SAR operated in continuous-flow mode. For 2500 ppm, use a SAR with a tight-fitting facepiece operated in continuous-flow mode or a SCBA with a full facepiece. For < 5000 ppm, use a SAR operated pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of nitrile, Viton, polyvinyl chloride, or chlorinated polyethylene to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles (Sec. 5).

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Purge all vessels previously containing *n*-hexane with steam before entering for the purpose of repair (cutting, welding). Refer to OSHA's Confined Space Standard (29 CFR 1910.119). **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the central and peripheral nervous systems, skin, eyes, and respiratory system.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Hexanes
DOT Hazard Class: 3
ID No.: UN1208
DOT Packing Group: II
DOT Label: Flammable Liquid
Special Provisions (172.102): T8

Packaging Authorizations
a) **Exceptions:** 173.150
b) **Non-bulk Packaging:** 173.202
c) **Bulk Packaging:** 173.242

Quantity Limitations
a) **Passenger Aircraft or Railcar:** 5L
b) **Cargo Aircraft Only:** 60L

Vessel Stowage Requirements
a) **Vessel Stowage:** E
b) **Other:**

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 139, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168, 171, 174
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 397A
Isohexanes

Issued 8/89 Revision: B, 8/89

Section 1. Material Identification

Isohexanes Description: Used as commercial solvents for vegetable oils, glues, coatings, and paints; found in gasoline and as intermediates for chemicals; and as constituents of rubber solvent and petroleum ether.
Other Designations: Hexane isomers other than *n*-hexane; C_6H_{14}; CAS No. 107-83-5.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

R 1
I 1
S 2
K 4

NFPA
HMIS
H 1
F 3
R 0
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Isohexanes, ca 100%*

OSHA PEL	ACGIH TLV, 1988-89	NIOSH REL, 1977	Toxicity Data†
8-hr TWA: 500 ppm, 1800 mg/m³	TLV-TWA: 500 ppm, 1800 mg/m³	10-hr TWA: 100 ppm, 350 mg/m³	Not listed
15-min STEL: 1000 ppm, 3600 mg/m³	TLV-STEL: 1000 ppm, 3600 mg/m³	15-min ceiling: 510 ppm, 1800 mg/m³	

* Hexane isomers, excluding *n*-hexane or straight chain hexane, are the major component of this product; however, possible contaminants are *n*-hexane, C_5 to C_7 saturated hydrocarbons, C_5 to C_7 olefinic hydrocarbons, and aromatic hydrocarbons.
† Monitor NIOSH, *RTECS* for future toxicity data specific to hexane isomers other than *n*-hexane.

Section 3. Physical Data

Boiling Point: 122 °F (50 °C) to 154.4 °F (68 °C)
Melting Point: ca -139 °F (-95 °C)
Vapor Density (Air = 1): 3.0
Molecular Weight: 86 g/mol
Specific Gravity (H_2O = 1): 0.66 at 68 °F (20 °C)
Water Solubility: Insoluble

Appearance and Odor: A clear, colorless, mobile, volatile, flammable liquid; a mild hydrocarbon odor.

Section 4. Fire and Explosion Data

Flash Point: -23°F (-30.56 °C) CC	Autoignition Temperature: 437 °F (223 °C)	LEL: 1.2% v/v	UEL: 8% v/v

Extinguishing Media: Use carbon dioxide (CO_2), foams, or dry chemical to put out isohexane fires. Directing solid streams of water into burning pools of liquid can scatter and spread the fire. Use water sprays to cool fire-exposed containers, prevent dangerous pressure rise and/or rupture, disperse vapors, and flush unignited spills away from sensitive exposures.
Unusual Fire or Explosion Hazards: The isohexanes are a very flammable, volatile liquid which burns like gasoline. They represent a dangerous fire and explosion hazard. Since they evaporate quickly, the resulting denser-than-air vapors can flow along surfaces, collect in low-lying or enclosed areas like sumps and utility rooms, reach distant ignition sources, and flash back to the original liquid.
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 5. Reactivity Data

Stability/Polymerization: Isohexanes are stable at room temperature during routine operations. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Isohexanes can react violently with strong oxidizing agents.
Conditions to Avoid: Never expose this liquid to ignition sources (heat, sparks, open flames, or uninsulated heating elements).
Hazardous Products of Decomposition: Thermal oxidative degradation of isohexane can produce carbon dioxide and toxic carbon monoxide (CO).

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists isohexanes as a carcinogen.
Summary of Risks: Excessive inhalation of isohexane vapors can irritate the respiratory tract and cause dizziness, lightheadedness, unconsciousness, and intoxication, depending upon the exposure's intensity and duration. Skin or eye contact with these liquid isohexane isomers couses irritation, redness, discomfort, and, for the skin, a defatting action which dissolves and strips away the protective fats and oils normally found on your skin's surface.
Medical Conditions Aggravated by Long-Term Exposure: None reported
Target Organs: Skin, eyes, and mucous membranes of the respiratory tract.
Primary Entry: Inhalation , ingestion, skin contact.
Acute Effects: Irritation of the skin, eyes, and mucous membranes of the respiratory system; dizziness, unconsciousness, and intoxication similiar to that following ingestion of excessive amounts of alcoholic beverages. A gasoline taste may occur. Severe exposure may cause severe nervous system depression, respiratory arrest, and death.
Chronic Effects: Prolonged or repeated skin contact may lead to contact dermatitis in certain individuals. Loss of nerve function in the hands and feet may occur.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: After rinsing affected area with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never induce vomiting! Severe aspiration hazard exists. If vomiting occurs spontaneously, lower victim's head to the knee level. Never give anything by mouth to an unconscious or convulsing person. Give several ounces of edible oil to drink.
After first aid, get appropriate in-plant, paramedic, or community medical attention and support.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice an isohexanes spill control and countermeasure plan (SCCP).* When a spill occurs,notify safety personnel, evacuate unnecessary personnel, eliminate heat and ignition sources, provide maximum explosion-proof ventilation, and implement the SCCP. Cleanup personnel should wear fireproof personal protective equipment (Sec. 8). **Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Subpart Z)
EPA Designations
Assigned the RCRA Hazardous Waste D001 (40 CFR 261.21, Ignitability)
Assigned the CERCLA Hazardous Substance (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg)
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Where splashing is possible, wear a full face shield. **Respirator:** Wear a NIOSH-approved respirator if necessary. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. **Ventilation:** Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL standards (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 103). **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, washing facilities, and properly serviced fire extinguishers. **Contaminated Equipment:** Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Launder contaminated clothing before wearing. Remove this material from your shoes and equipment. **Other:** Preplacement and periodic medical exams focusing on the skin and the central nervous system are advised. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics. Handle thid flammable, material with appropriate caution.

Section 9. Special Precautions and Comments

Storage Requirements: Store isohexanes in closed containers in a cool, dry, well-ventilated, fireproof area away from heat and ignition sources and incompatible chemicals. Protect these containers from physical damage; shield them from direct sunlight.
Engineering Controls: To prevent static sparks, electrically ground and bond all containers, tank cars, and pipes used in shipping, receiving, or transferring operations in production and storage areas. Electrical services, including lights, must be sparkproof.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Hexane
DOT Hazard Class: Flammable liquid
DOT ID No. : UN1208
DOT Label: Flammable liquid
DOT Packaging Requirements: 49 CFR 173.119
DOT Packaging Exceptions: 49 CFR 173.118

IMO Shipping Name: Hexane *(and its isomers)*
IMO Hazard Class: 3.1
IMO Label: Flammable liquid
IMDG Packaging Group: II

MSDS Collection **References:** 1, 6, 7, 84-94, 100, 116, 117, 119, 120, 122
Prepared by: PJ Igoe, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD
M6

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Material Safety Data Sheets Collection:

Sheet No. 420
Acetone Solvent Blend

Issued: 4/79 Revision: A, 9/91

Section 1. Material Identification

35

Acetone Solvent Blend Description: A mixture of acetone and isopropanol. Used as a solvent for fats, oils, waxes, rubber, plastics, varnishes, gums, resins and rubber cements.
Other Designations: Acetone, CAS No. 0067-64-1; isopropyl alcohol, CAS No. 0067-63-0.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I 1
S 2
K 3

NFPA
3
1 0
-

HMIS
H 1
F 3
R 0
PPG†
† Sec. 8

Cautions: Acetone solvent blend is a skin, eye, and mucous membrane irritant. It may be narcotic in high concentrations.

Section 2. Ingredients and Occupational Exposure Limits

Acetone, >60%
Isopropanol, 10 to 30%

1990 OSHA PELs
Acetone: 8-hr TWA: 750 ppm, 1800 mg/m³
15-min STEL: 1000 ppm, 2400 mg/m³
Isopropyl alcohol: 8-hr TWA: 400 ppm, 980 mg/m³
15-min STEL: 500 ppm, 1225 mg/m³

1990-91 ACGIH TLVs
Acetone: TWA: 750 ppm, 1,780 mg/m³
STEL: 1000 ppm, 2400 mg/m³
Isopropyl alcohol: TWA: 400 ppm, 985 mg/m³
STEL: 500 ppm, 1,230 mg/m³

1990 NIOSH RELs
Acetone: TWA: 250 ppm, 590 mg/m³
Isopropyl alcohol: 400 ppm, 980 mg/m³

1985-86 Toxicity Data*
Acetone: Man, oral, TD_{Lo}: 2857 mg/kg
Man, inhalation, TD_{Lo}: 440 µg/m³/6 min
Isopropyl alcohol: Man, oral, LD_{Lo}: 5272 mg/kg
Human, oral, LD_{Lo}: 3570 mg/kg; toxic effects include central nervous system, pulmonary, and gastrointestinal

Calculated TLV for Acetone (70%) Isopropanol (30%) Mixture: 596 ppm

* See NIOSH, *RTECS* (AL3150000, NT8050000) for additional toxicity data on acetone and isopropyl alcohol, respectively.

Section 3. Physical Data

Boiling Point: 133 to 181 °F (56 to 83 °C) at 1 atm
Vapor Pressure: ca 225 mm Hg at 77 °F (25 °C)
Vapor Density (air = 1): ca 2
Density/Specific Gravity (20 °C/20 °C): 0.79
Water Solubility: Completely soluble
% Volatile by Volume: ca 100*

Appearance and Odor: A clear, colorless liquid with an acetone odor.

* Acetone solvent blend is a very volatile liquid that increases fire/explosion risk, especially at elevated temperatures.

Section 4. Fire and Explosion Data

Flash Point: 0 to 53 °F (-17.8 to 11.7 °C), CC	**Autoignition Temperature:** >750 °F (399 °C)*	**LEL:** 2.0% v/v	**UEL:** 12.0% v/v

Extinguishing Media: Alcohol foam, dry chemical, or carbon dioxide (CO_2). Use smothering effect to extinguish fire. Waterspray may be ineffective for extinguishing, but it is useful in cooling fire-exposed containers, in reducing fire intensity, and for diluting and flushing solvent.
Unusual Fire or Explosion Hazards: Acetone solvent blend is an OSHA Class 1B liquid. Fire and explosion hazards exist when this material is exposed to heat or ignition sources. Vapors may travel to an ignition source and flash back.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Stay upwind. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode, and full protective equipment. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

* An estimated value.

Section 5. Reactivity Data

Stability/Polymerization: Acetone solvent blend is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Acetone solvent blend is incompatible with strong oxidizing agents, strong acids, and strong alkalies.
Conditions to Avoid: Avoid heat and ignition sources.
Hazardous Products of Decomposition: Thermal oxidative decomposition of acetone solvent blend can produce carbon monoxide.

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Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC, NTP, and OSHA do not list acetone solvent blend as a carcinogen.
Summary of Risks: Excessive vapor inhalation can cause mucous membrane and respiratory tract irritation. Eye contact can cause severe irritation. Prolonged or repeated skin contact can defat skin. It may be narcotic in high concentrations.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, respiratory system, and central nervous system (CNS).
Primary Entry Routes: Inhalation, skin contact.
Acute Effects: Symptoms include respiratory tract irritation, nasal irritation, conjunctiva irritation, cough, headache, fatigue, dizziness, narcosis, and even asphyxiation. Skin contact causes dryness, irritation, and mild dermatitis. Ingestion produces gastrointestinal (GI) tract irritation and nausea. Injury to the kidneys is associated with ingestion of isopropyl alcohol and could potentially occur with significant ingestions of acetone solvent blend. Aspiration of vomitus into the lungs is a hazard and can result in severe illness or even death.
Chronic Effects: None reported.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If a small amount is ingested, have that *conscious and alert* person drink 1 to 2 glasses of water. Consult a physician.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Accidental or intentional ingestion may result in a state of intoxication difficult to distinguish from ethanol ingestion. Serum acetone and alcohol levels may be necessary to diagnose and monitor such a patient's status. In severe intoxication, arterial blood gases and pH, blood electrolytes, liver function studies, a baseline creatinine, blood counts, and urinalysis may be indicated. Watch for deteriorating CNS and respiratory function.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of large spills, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide maximum, explosion-proof ventilation. Cleanup personnel should protect against inhalation and skin or eye contact. For small spills, 1) absorb liquid with a noncombustible, absorbent material, and dispose; or 2) absorb on paper and burn. For large spills, dike far ahead to contain and collect for recycle or disposal. Use nonsparking tools to place waste liquid or absorbent in closable containers for disposal. Keep waste out of sewers, watersheds, or waterways. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Degradation: When released on soil, acetone solvent blend probably both volatilizes and leaches into the ground and probably biodegrades. If released into water, it probably also biodegrades.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.21): Ignitable Waste
Acetone is listed as a RCRA Hazardous Waste (40 CFR 261.33)
Acetone is listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Acetone and isopropyl alcohol are listed as SARA Toxic Chemicals (40 CFR 372.65)
OSHA Designations
Acetone and isopropyl alcohol are listed as Air Contaminants (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles where necessary, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious natural rubber gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a clean, cool, well-ventilated area away from heat and ignition sources, oxidizing agents, strong acids, and bases. Protect containers from physical damage. Emptied containers may still be hazardous from residual liquid or vapors. Store and handle as an OSHA Class 1B flammable liquid.
Engineering Controls: Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Make sure all engineering systems are of maximum explosion-proof design. Acetone solvent blend presents a dangerous fire and explosion hazard; perform all work operations involving it carefully and in a way that prevents exposing liquid or its vapor to ignition sources. To prevent static sparks, electrically ground and bond all containers and pipelines used in shipping, transferring, reacting, production, and sampling operations. Consider automatic sprinkler systems for fire protection in work areas.

Transportation Data (49 CFR 172.101, .102): See acetone and isopropyl alcohol (*MSDS Collection*, Nos. 300 and 324)

MSDS Collection **References:** 1, 2, 26, 38, 73, 84-94, 100, 101, 103, 116, 117, 120, 122, 124, 126, 132, 136, 138, 143, 146, 148, 159
Prepared by: M Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD ; **Edited by:** JR Stuart, MS

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Material Safety Data Sheet

From Genium's Reference Collection

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GENIUM PUBLISHING CORP.

NO. 417
PHTHALIC ANHYDRIDE
(Revision A)

Issued: June 1979
Revised: May 1986

SECTION 1. MATERIAL IDENTIFICATION

21

MATERIAL NAME: PHTHALIC ANHYDRIDE
OTHER DESIGNATIONS: Phthalic Acid Anhydride, 1,2-Benzenedicarboxylic Acid Anhydride, Phthalandione, PAN, PA, $C_6H_4(CO)_2O$, CAS #0085-44-9, ASTM D2403
MANUFACTURER/SUPPLIER: Available from many suppliers, including:
Allied Corp., Chemical Sector, PO Box 1087R, Morristown, NJ 07960;
Telephone: 800-631-8050
Chevron USA, Inc., Petrochemicals Div., 575 Market St., San Francisco, CA 94120;
Telephone: (415) 894-4520
Monsanto Co., 800 N. Lindbergh Blvd., St. Louis, MO 63166;
Telephone: (314) 694-1000

HMIS
H: 2
F: 0
R: 0
PPE*
*See Sect. 8

R 1
I 4
S 2
K 1

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Phthalic Anhydride , CAS #0085-44-9	>99	8-hr TWA: 2 ppm* or 12 mg/m^3 Rat, Oral, LD_{50}: 4020 mg/kg Mouse, Oral, LD_{50}: 2 g/kg Guinea Pig, Oral, LDLo: 100 mg/kg
* Current OSHA PEL. ACGIH (1985-86) TWA is 1 ppm or 6 mg/m^3 with a 4-ppm STEL.		

SECTION 3. PHYSICAL DATA

Boiling Point, 1 atm ... ca 543°F (295°C); Sublimes @ 543°F (284°C)
Vapor Pressure @ 20°C, mm Hg ... < 0.05
@ 30°C, mm Hg ... 0.001
Water Solubility, % ... 0.62
Vapor Density (Air = 1) ... 5.1
Specific Gravity, 4/4C ... 1.527
Melting Point ... 267.8°F (131°C)
Percent Volatile by Volume ... Not Found
Molecular Weight ... 148.1

Appearance and odor: A white, crystalline, solid, or clear molten liquid with an irritating, choking odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp.	Flammability Limits in Air	LOWER	UPPER
304°F (152°C) CC	1058°F (569°C)	% Volume	1.7	10.4

EXTINGUISHING MEDIA: Carbon dioxide or dry chemical can be used on solid or molten phthalic anhydride. Water spray is effective on its flake or dust. Molten material solidifies and hydrolyzes on contact with water, which generates steam. Steam or inert gas is effective on fires in tanks. UNUSUAL FIRE/EXPLOSION HAZARDS: Both vapors and dust of this combustible material may burn in air. A severe dust explosion can occur at or above 0.015 oz/ft^3 of air-dispersed particulate. The ignition temperature for the dust cloud is 1202°F (650°C). Inerting air with CO_2 to below 14% oxygen will prevent dust explosions. SPECIAL FIRE-FIGHTING PROCEDURES: Fire fighters should use self-contained breathing apparatus and wear fully protective clothing.

SECTION 5. REACTIVITY DATA

Phthalic anhydride is stable. Hazardous polymerization cannot occur.

This is a combustible material whose vapors will burn. Pyrophoric phthalic acid salts can be formed from it in the presence of iron.

CONDITIONS TO AVOID: Keep phthalic anhydride away from sources of ignition and open fire. It reacts with moisture in air to form phthalic acid, which can corrode metals, liberating hydrogen. Use a dry, inert gas (nitrogen or carbon dioxide) to blanket storage tanks.
Hazardous products of decomposition of this material are oxides of carbon.

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SECTION 6. HEALTH HAZARD INFORMATION

Phthalic anhydride is not listed as a carcinogen by the NTP, IARC, or OSHA.

SUMMARY OF RISKS: It is a primary irritant to the mucous membranes and the upper respiratory tract, resulting in coughing and sneezing with a burning sensation in the nose and throat (>4 ppm). Excessive exposure may cause inflammation of the respiratory tract, nasal bleeding and ulceration, loss of smell, hoarseness, bronchitis, and blood changes. Chronic exposure by inhalation or skin contact can result in allergic sensitization. Skin or eye contact with solid or vapors can be irritating. Contact with molten phthalic anhydride will produce severe thermal burns aggravated by chemical effects. Phthalic anhydride in the presence of moist tissue hydrolyzes to phthalic acid, which causes irritating effects.

TARGET ORGANS: Skin, upper respiratory tract. PRIMARY ENTRY: Inhalation. ACUTE EFFECTS: Primary irritant. CHRONIC EFFECTS: Asthma.

FIRST AID: EYE CONTACT: Flush with plenty of running water for 15 minutes. Get medical help.* SKIN CONTACT: Wash areas of contact thoroughly with soap and water. Promptly remove contaminated clothing. If a burn occurs, remove material from skin; treat for thermal burn and possible shock. INHALATION: Remove victim to fresh air. Get medical help immediately.* Spray or gargle with water to help relieve nasal or throat irritation. Administer oxygen to victim if breathing is difficult or if violent coughing occurs. INGESTION: Give victim lots of soapy water to drink and induce vomiting. Get medical help.* Do not give anything by mouth to an unconscious person.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Notify safety personnel if large phthalic anhydride spills occur. Eliminate ignition sources; provide ventilation that will not stir up dust. Exclude all unnecessary personnel from area. Cleanup personnel need protection against liquid contact and dust/vapor inhalation.

Contain the spill; scoop up the solid (or solidified melt) with nonsparking tools and place it into a dry metal container for reclamation or disposal. Avoid generating phthalic anhydride dust. Neutralize trace residues or very small spills with lime-soda ash or sodium bicarbonate and water.

DISPOSAL: Burn scrap material in an approved incinerator equipped with an afterburner. Phthalic anhydride may be dissolved in a flammable solvent to improve burning. Follow Federal, state, and local regulations.

EPA (RCRA) Hazardous Waste No.: U190

SECTION 8. SPECIAL PROTECTION INFORMATION

Wear chemical safety goggles. Wear rubber, neoprene, or vinyl gloves and suitable protective clothing to prevent skin contact with phthalic anhydride.

For emergency and nonroutine use above the TLV, use a NIOSH-approved full-facepiece respirator with a dust filter and organic vapor-acid gas canister combination. For higher concentrations, use a self-contained or air-supplied respirator.

Use general ventilation plus local exhaust ventilation to control dust, fumes, or vapors. Local exhaust should have a velocity of 100 lfm (linear feet per minute).

Ventilation system and electrical equipment should be explosion proof. Where solutions or molten material are handled, rubber boots, rubber apron, impervious clothing, and a face shield, etc., may be required for suitable protection against contact with phthalic anhydride.

Provide eyewash station and chemical safety shower in areas of handling and use.

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

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store solid phthalic anhydride in closed containers in a cool, dry, fire-resistant area away from sources of heat, sources of ignition, and incompatible materials like strong oxidizing agents, alkaline materials, etc.

Electrically ground handling equipment to prevent static sparks that can be generated when transferring this material. Blanket molten phthalic anhydride storage with inert gas. Stored liquid should be kept below 300°F (148.9°C). Install a vent to an outside area. Diking of sufficient capacity to match the material's full tankage volume should be established.

Provide preplacement medical examinations for workers; preclude from exposure those with pulmonary or dermal disorders or those who have become sensitized. Prevent skin contact and breathing dust or vapors of this material. Follow good hygienic practices.

DOT No. UN2214 (Solid, Molten)

Data Source(s) Code: 1, 2, 4-12, 16, 18, 23, 38, 49, 82, 84. CK

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Approvals JO Accrocco, 1/87.

Indust. Hygiene/Safety JW 1-87

Medical Review [signature] Jan 87

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Material Safety Data Sheets Collection:

Sheet No. 414
Di(2-ethylhexyl)phthalate

Issued: 12/84 Revision: A, 11/90

Section 1. Material Identification

R 0
I 2
S 2
K 1

NFPA
1
0 0
-

HMIS
H 0
F 1
R 0
PPG*
* Sec. 8

Di(2-ethylhexyl)phthalate ($C_{24}H_{38}O_4$) Description: Prepared by acid-catalyzed reaction of 2-ethylhexanol with phthalic anhydride. Used in plasticizing a variety of polymeric materials such natural rubber, synthetic rubber, nitrocellulose, ethyl cellulose, cellulose acetate butyrate, polymethyl methacrylate, polyvinyl butyral, polyvinylidine chloride, and polystyrene; as an organic pump fluid; as a testing agent for air filtration systems, a component of dielectric fluids in electrical capacitors, an inert ingredient in pesticide formulations; in liquid soaps, detergents, rubbing alcohol, decorative inks, lacquers, photographic film, wire and cable, adhesives, industrial and lubricating oils, munitions, and defoaming agents used during paper and paperboard manufactures.

Other Designations: CAS No. 0117-81-7, 1, 2-benzenedicarboxylic acid bis(2-ethylhexyl) ester, DEHP, di-sec-octyl phthalate, dioctyl phthalate, DOP, octyl phthalate.

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

Cautions: Di(2-ethylhexyl)phthalate is a possible human carcinogen. Di(2-ethylhexyl)phthalate is a mild skin, eye, and mucous membrane irritant. It affects the gastrointestinal (GI) tract.

Section 2. Ingredients and Occupational Exposure Limits

Di(2-ethylhexyl)phthalate, ca 100%

1989 OSHA PEL
8-hr TWA: 5 mg/m³

1990-91 ACGIH TLVs
TWA: 5 mg/m³
STEL: 10 mg/m³

1988 NIOSH REL
Reduce to lowest feasible limit

1985-86 Toxicity Data*
Man, oral, TD_{Lo}: 143 mg/kg ingested produces gastrointestinal effects
Rat, oral, LD_{50}: 30600 mg/kg
Rabbit, skin, LD_{50}: 25 gm/kg; toxic effects not yet reviewed

* See NIOSH, *RTECS* (TI0350000), for additional irritative, mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 446 °F (230 °C) at 5 mm Hg
Melting Point: -58 °F (-50 °C)
Vapor Pressure: 1.32 mm Hg at 392 °F (200 °C)
Vapor Density (Air = 1): 16
1 ppm = ~15.94 mg/m³
Appearance and Odor: Light colored liquid with a slight odor.

Molecular Weight: 390.54
Specific Gravity (20°C/20°C): 0.9861
Water Solubility: <0.01% in water at 77 °F (25 °C)
Viscosity: 81.4 centipoise at 20 °C
Pour Point: -50.8 °F (-46 °C); 8.2 lb/gal at 20 °C

Section 4. Fire and Explosion Data

Flash Point: 420 °F (215 °C), OC	Autoignition Temperature: 735 °F (390 °C)	LEL: 0.3% v/v at 474 °F (245 °C)	UEL: None reported

Extinguishing Media: Use dry powder, carbon dioxide, or foam to fight a fire involving di(2-ethylhexyl)phthalate. Water or foam may cause frothing.

Unusual Fire or Explosion Hazards: This material offers no unusual fire hazards beyond those encountered with ordinary combustible materials.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Di(2-ethylhexyl)phthalate is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: This OSHA Class III-B combustible liquid is incompatible with strong oxidizing agents.

Hazardous Products of Decomposition: Thermal oxidative decomposition of di(2-ethylhexyl)phthalate can produce acrid smoke and fumes including carbon dioxide and carbon monoxide.

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Section 6. Health Hazard Data

Carcinogenicity: The NTP and IARC list di(2-ethylhexyl)phthalate as an anticipated human carcinogen and possible human carcinogen (Group 2B), respectively. Experimental studies show that di(2-ethylhexyl)phthalate has teratogenic effects in laboratory animals.

Summary of Risk: Di(2-ethylhexyl)phthalate is a mild skin and eye irritant. It affects the human gastrointestinal tract since it is absorbed intact from the gastrointestinal tract. However, when administered either intravenously or orally, it is rapidly metabolized to derivatives excreted mainly in urine or bile. Central nervous system (CNS) depression may occur, especially with ingestion of large amounts. Skin sensitization does not occur in humans. Inhalation of any significant amount is probably unlikely due to the low vapor pressure. Di(2-ethylhexyl)phthalate has become an environmental contaminant that may accumulate in the food chain.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Target Organs: Eyes, upper respiratory system, skin, central nervous system.

Primary Entry Routes: Inhalation, ingestion.

Acute Effects: Symptoms of overexposure include conjunctivitis, keratitis (inflammation of the eye's cornea), bronchial irritation, eczema, staggering, abdominal cramps, nausea, and diarrhea. CNS depression—lethargy, drowsiness, staggering, and sleepiness—can result from absorbing large amounts.

Chronic Effects: None reported.

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting*. Consult a physician immediately.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel. Contain and pick up spilled material with some noncombustible absorbent material. For large spills, dike far ahead to contain. Place in appropriate containers for disposal. Prevent losses into the environment whenever possible. Do not release to sewers or waterways. This material degrades in fresh water sediments under aerobic conditions; half-life is ~14 days. It does not degrade under anaerobic conditions. It is readily concentrated by aquatic organisms. Clean up trace residues with water and detergent. Follow applicable OSHA regulations (29 CFR 1910.120).

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33); Waste No. U028

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.45 kg) [* per RCRA, Sec. 3001]

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact.

Ventilation: Provide general and local ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLVs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a well-ventilated area away from oxidizing agents and heat and ignition sources. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas.

Engineering Controls: Avoid prolonged or repeated contact with liquid and inhalation of mist or vapors. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.

Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection **References:** 1-12, 14, 23, 38, 47, 73, 101, 103, 124, 126, 127, 132, 133, 136, 138, 143, 146

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 410
Carbon Tetrachloride

Issued: 12/80 Revision: B, 4/90

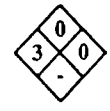
Section 1. Material Identification

31

Carbon Tetrachloride Description: A chlorinated hydrocarbon derived from interacting carbon disulfide and chlorine in the presence of iron, or chlorination of methane or higher hydrocarbons at 482 °F/250 °C to 752 °F/400 °C. Carbon tetrachloride is treated with caustic alkali solution to remove sulfur chloride. Its primary use is in manufacturing flurocarbon propellants. It is also used in producing of semiconductors, chlorinating organic compounds, metal degreasing, refrigerants; as a solvent for oils, fats, resins, rubber waxes, lacquers, and varnishes; and as an agricultural fumigant. This material was widely used in the dry-cleaning industry.
Other Designations: CAS No. 0056-23-5; CCl_4; carbon chloride; carbon tet; methane tetrachloride; perchloromethane; tetrachlorocarbon; tetrachloromethane.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.

R 1
I 4
S 2*
K 0
*Skin absorption

NFPA



HMIS
H 3
F 0
R 0
PPG†
† Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Carbon tetrachloride, ca 100%

OSHA PEL
8-hr TWA: 2 ppm, 12.6 mg/m³

ACGIH TLV (Skin), 1989-90
TLV-TWA: 5 ppm, 31 mg/m³

NIOSH REL, 1987
60-min ceiling: 2 ppm, 12.6 mg/m³

Toxicity Data*
Rat, oral, LD_{50}: 2800 mg/kg; toxic effects not yet reviewed
Rat, inhalation, LC_{50}: 8000 ppm over 4 hr; no toxic effect noted
Human, inhalation, TC_{Lo}: 20 ppm inhaled produces gastrointestinal effects (nausea or vomiting)

* See NIOSH, *RTECS* (FG4900000), for additional irritative, mutative, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 169.77 °F/76.54 °C
Melting Point: -9.4 °F/-23 °C
Vapor Pressure: 91.3 mm Hg at 68 °F/20 °C
Vapor Density (Air = 1): 5.32
Molecular Weight: 153.84 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.5940 at 68 °F/20 °C
Water Solubility: Very slightly soluble (800 mg/l at 68 °F/20 °C)
Evaporation Rate (Butyl Acetate = 1): 12.8

Appearance and Odor: A colorless liquid with a heavy ethereal odor. The high and low odor thresholds are, respectively, 128.4 and 60 mg/m³. Odor is not an adequate warning sign to prevent overexposure.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: Carbon tetrachloride is nonflammable and will not support combustion. Use extinguishing media appropriate to the surrounding fire. This material was previously used as an extinguishing medium in portable fire extinguishers, but its toxicity and fire decomposition products lead to its replacement with "safer" extinguishing media.
Unusual Fire or Explosion Hazards: Carbon tetrachloride can react violently with hot or burning metals such as aluminum and magnesium.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and fully encapsulating suit. Use water spray to cool fire-exposed containers. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Carbon tetrachloride is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Carbon tetrachloride reacts violently with fluorine gas, alkali metals, and aluminum (see reference 126 for specific incompatibilities).
Conditions to Avoid: This material has caused explosions when used as a fire extinguisher on wax fires and uranium fires. It may also form toxic phosgene when used to put out electrical fires.
Hazardous Products of Decomposition: Thermal oxidative decomposition of carbon tetrachloride can produce toxic phosgene and hydrogen chloride.

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Section 6. Health Hazard Data

Carcinogenicity: The NTP, IARC, and ACGIH list carbon tetrachloride as an anticipated human carcinogen, a possible human carcinogen, and a suspected human carcinogen, respectively.
Summary of Risks: Carbon tetrachloride is highly toxic and irritating by inhalation, ingestion (mean lethal dose is 5 to 10 ml), and skin absorption. Alcohol's synergistic effects markedly increase CCl_4's toxicity. Excessive exposure may result in central nervous system depression, cardiac arrhythmias, and gastrointestinal symptoms. In humans the majority of fatalities have been the result of renal injury with secondary cardiac failure. Kidney and liver damage can occur from severe acute or chronic exposure. Human liver damage occurs more often after ingestion of the liquid than after the inhalation of the vapor. However, after a 30 min to 1 hr exposure to concentrations of 1000 to 2000 ppm, humans have died from acute renal damage.
Medical Conditions Aggravated by Long-Term Exposure: Prolonged recovery and permanent disability of the liver, kidney, and lungs are possible.
Target Organs: Central nervous system, eyes, skin, liver, kidneys, lungs.
Primary Entry Routes: Inhalation, percutaneous (through the skin).
Acute Effects: Acute exposure symptoms include eye, nose, skin, and throat irritation; cough, dyspnea, cyanosis, cardiac arrhythmias, headaches, dizziness, mental confusion, nausea, vomiting, abdominal pain, and diarrhea. Jaundice and abnormal liver enlargement accompanied by oliguria (reduced excretion of urine), proteinuria (protein in urine), and hematuria (blood in urine) may occur even after several days delay.
Chronic Effects: Chronic exposure symptoms include defatting dermatitis, headaches, dizziness, mental confusion, apathy, anorexia, nausea, vomiting, abdominal pain, weight loss, narrowing of visual field, optic nerve damage with possible blindness, hearing loss, and renal and hepatic decompensation (loss of these organs' ability to correct dysfunction). Chronic exposure may result in the development of aplastic anemia.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Give one to two glasses of water to dilute and induce vomiting, unless the person shows evidence of decreasing mental functioning and awareness.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: To minimize hepatorenal damage, consider intravenous acetylcysteine. Hyperbaric oxygen is also utilized for significant exposures. Dialysis has also been suggested in severe cases. Give cardiorespiratory support as indicated and carefully monitor fluid and electrolytes. Closely monitor hepatic and renal functions. Avoid epinephrine because of myocardial sensitization and potential for inducing ventricular arhythymias.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate area, and provide maximum exhaust ventilation. Cleanup personnel should protect against inhalation and skin and eye contact. Small spills can be absorbed on paper or some noncombustible, inert ingredient and allowed to evaporate in a hood. For large spills, dike far ahead to contain spill for disposal. Prevent release of CCl_4 to surface water or sewers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33)
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per RCRA, Sec. 3001, per Clean Water Act, Sec. 307(a), 311 (b)(4)]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol protective gear is recommended.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL, ACGIH TLV, and NIOSH REL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed container in a cool, dry, well-ventilated, low fire-risk area away from incompatible materials (Sec. 5), direct sunlight, and heat. Prevent exposure of vapors to high temperature to prevent decomposition to toxic and corrosive gases and vapors.
Engineering Controls: Avoid vapor inhalation and skin or eye contact. Use only with adequate ventilation and appropriate personal protective gear. Monitor vapor levels and institute a respiratory protection program which includes training, maintenance, inspection, and evaluation. Practice good personal hygiene procedures. When possible, substitute a less hazardous solvent for CCl_4. Provide preplacement and biannual medical exams, including studies of liver and kidney function. Prevent exposing individuals with liver, kidney, or central nervous system diseases, or alcoholism. Alcohol's synergistic effects markedly increase CCl_4's toxicity.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Carbon tetrachloride
DOT Hazard Class: ORM-A
ID No.: UN1846
DOT Label: None
DOT Packaging Requirements: 173.620
DOT Packaging Exceptions: 173.505

IMO Shipping Name: Carbon tetrachloride
IMO Hazard Class: 6.1
IMO Label: Poison
IMDG Packaging Group: II
ID No.: UN1846

MSDS Collection **References:** 7, 26, 38, 53, 73, 84, 85, 88, 89, 100, 103, 109, 124, 126, 127, 129, 130, 131, 134, 136, 137
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD MS

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Material Safety Data Sheet

From Genium's Reference Collection
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GENIUM PUBLISHING CORP.

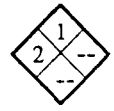
No. 402
BENZOIC ACID
(Revision A)

Issued: November 1978
Revised: February 1987

SECTION 1. MATERIAL IDENTIFICATION

22

MATERIAL NAME: BENZOIC ACID



DESCRIPTION/USES: Used in plasticizers, food preservatives, tobacco seasoning, flavors, perfumes, dentifrices, and as an antifungal agent.

OTHER DESIGNATIONS: Benzenecarboxylic Acid, Phenyl Carboxylic Acid, Phenylformic Acid, C_6H_5COOH, CAS #0065-85-0

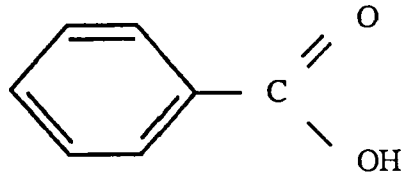
MANUFACTURER/SUPPLIER: Available from many suppliers, including:
Velsicol Chemical Corp., 341 E. Ohio St., Chicago, IL 60611;
Telephone (312) 670-4500

HMIS

H 1	
F 1	R 1
R 0	I --
PPE*	S 1
*See Sect. 8	K 1

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Benzoic Acid, CAS #0065-85-0	100%	No TLV Established. Human, Skin, 22 mg/3 days, Intermittent: Moderate Irritation Man, Oral, LDLo: 500 mg/kg Rat, Oral, LD_{50}: 2530 mg/kg Rabbit, Eye, 100 mg: Severe Irritation



SECTION 3. PHYSICAL DATA

Boiling Point at 1 atm ...480.6°F (249.2°C)
(Sublimes at 100°C and readily steam distills)
Vapor Pressure at 96°C, mm Hg ... 1.0
Vapor Density (Air=1) ... 4.2
Water Solubility at 25°C, g/liter ... 2.9

Specific Gravity (H_2O=1) ... 1.3
Molecular Weight ... 122.1
Melting Point ... ca 251.6°F (122°C)
Percent Volatile by Volume ... Negligible

Appearance and odor: Colorless-to-white solid: crystals, powder, platelets, scale (technical-grade flake can also be tan colored); benzoin- or benzaldehydelike odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
249.8°F (121°C), CC	1065.2°F (574°C)	Not Found	--	--

EXTINGUISHING MEDIA: Use dry chemical, carbon dioxide, foam, water spray, or fog to extinguish a benzoic acid fire.

UNUSUAL FIRE/EXPLOSION HAZARDS: High concentrations of benzoic acid dust particles in the air may form an explosive mixture. Vapors from hot or molten benzoic acid may form explosive mixtures with air.

SPECIAL FIRE-FIGHTING PROCEDURES: This combustible material is a slight fire hazard when exposed to heat or flames. Fire fighters should wear protective clothing and use self-contained breathing apparatus when fighting fires involving it.

SECTION 5. REACTIVITY DATA

Benzoic acid is stable. Hazardous polymerization cannot occur.

As a carboxylic acid, this material reacts exothermically with strong bases and can generate hydrogen gas when a water solution made from it reacts with metals.

Avoid combining benzoic acid with strong oxidizing agents.

Hazardous products of decomposition can include phenol, benzene, carbon monoxide, and carbon dioxide.

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SECTION 6. HEALTH HAZARD INFORMATION

Benzoic acid is not listed as a carcinogen by the NTP, IARC, or OSHA.
Inhalation of this material's dust or vapors may cause irritation of the upper respiratory tract. Prolonged or repeated contact may result in irritation. Contact with eyes can cause serious eye irritation and possible injury. Ingestion of excessive amounts may cause nausea, gastrointestinal disorders, and/or allergic response.
TARGET ORGANS: Eyes. PRIMARY ENTRY: Inhalation. ACUTE EFFECTS: Extremely irritating and corrosive to eyes. CHRONIC EFFECTS: Unknown.

FIRST AID: EYE CONTACT: Flush eyes thoroughly, including under eyelids, with running water for 15 minutes. Get medical help.* SKIN CONTACT: Remove contaminated clothing. Flush affected area with water; wash with soap and water. Get medical help.* INHALATION: Remove victim to fresh air. Restore and/or support his breathing as required. Get medical help.* INGESTION: Rinse victim's mouth with water. Give him 2 to 3 glasses of water to drink to dilute the material. Induce vomiting. Do not induce vomiting or give anything by mouth to someone who is unconscious or convulsing. Get medical help.*

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Notify safety personnel of benzoic acid spills or leaks. Cleanup personnel should use appropriate personal protection equipment (see sect. 8). Sweep up solid material and place it in drums for disposal. Avoid raising benzoic acid dust.

DISPOSAL: Bury waste in an approved landfill or incinerate it under controlled conditions. Follow Federal, state, and local regulations.

EPA, Clean Water Act, Reportable Spill Quantity: 5,000 lbs (40 CFR 117.3)

SECTION 8. SPECIAL PROTECTION INFORMATION

Supplier recommends a C-241 respirator with a C-241-1 filter for protection from dust.

Provide general dilution and local exhaust ventilation in sufficient volume and pattern to keep concentration of hazardous ingredients listed in section 2 below the minimal exposure at which irritation may occur.

Wear appropriate protective clothing such as chemical safety goggles and/or a full face shield to prevent skin or eye contact when working around hot or molten benzoic acid.

Eyewash stations and washing facilities should be readily accessible in areas of use and handling.

Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them. Particles may adhere to contact lenses and cause corneal damage.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store benzoic acid in tightly closed containers in a cool, dry, well-ventilated area away from oxidizing agents, strong bases, and sources of heat or ignition.
Molten benzoic acid is very hot (251.6°F [122°C]). Its vapors sublime readily and condense on cold surfaces, and this can block vent openings.
Avoid breathing benzoic acid dust. Prevent contact of this material with your eyes. Minimize its contact with your skin by wearing proper gloves and suitable work clothing. Practice good personal hygiene. Wash thoroughly after handling it. Do not take this material out of your work area or to your home on your clothing or equipment. Do not eat benzoic acid.

Benzoic acid is designated as a hazardous substance by the EPA (40 CFR 116).
DOT Classification: ORM-E DOT ID No. NA9094
Data Source(s) Code: 1, 2, 4-12, 14, 23, 42, 55, 58, 82, 84. CK

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Approvals	
Indust. Hygiene/Safety	4/87
Medical Review	May 87

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Material Safety Data Sheets Collection:

Sheet No. 409
Cresol (Mixed Isomers)

Issued: 12/78 Revision: B, 3/92

Section 1. Material Identification

Cresol, *mixed isomers* ($CH_3C_6H_4OH$) **Description:** Derived from coal tar or petroleum. Cresol is marketed by individual isomer and as pure or crude cresol. Pure cresol is a mixture of *ortho*, *meta*, and *para* isomers. Crude cresol (commercial cresol) is prepared by distilling "grey phenic acid" at 356 to 401 °F (180 to 205 °C) and is comprised of 20% *ortho*, 40% *meta*, and 30% *para* isomers, plus small amounts of phenol and xylenols. Each isomer can be prepared synthetically by diazotization of the specific corresponding toluidine. Used in manufacturing synthetic resins, explosives, photographic developers, petroleum, paint, disinfectants, and fumigants; as an ore flotation agent; and in the agriculture industry for herbicides and insecticides.
Other Designations: CAS No. 1319-77-3, Bacillol, cresylic acid, Tekresol, tricresol.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Cresol is severely irritating to mucous membranes, eyes, and skin. Depending on the cresol concentration, extent of exposure, and amount of skin exposed, toxicity may be slight (irritation) or severe (permanent injury or death).

R 1
I 4
S 3*
K 2
* Skin absorption

NFPA

HMIS
H 3
F 2
R 0
PPG†
† Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Cresol (*mixed isomers*) National Formulary (NF) grade contains < 5% phenol

1990 OSHA PEL (Skin)
8-hr TWA: 5 ppm (22 mg/m³)

1990 NIOSH REL
TWA: 5 ppm (22 mg/m³)

1990 IDLH Level
250 ppm

1991-92 ACGIH TLV (Skin)
TWA: 5 ppm (22 mg/m³)

1990 DFG (Germany) MAK
TWA: 5 ppm (22 mg/m³) (H)*
Peak Exposure Limit: 10 ppm, 5 min, momentary value/8 per shift

1985-86 Toxicity Data†
Rat, oral, LD_{50}: 1454 mg/kg; toxic effects not yet reviewed
Mouse, inhalation, LC_{50}: 179 mg/m³/2 hr; no toxic effects noted (*o*-)
Rabbit, eye: 103 mg produced severe irritation (*p*-)
Rabbit, skin: 517 mg applied for 24 hr produced severe irritation (*m*-)
Rabbit, skin, LD_{50}: 2000 mg/kg; toxic effects not yet reviewed

* Danger of cutaneous absorption.
† See NIOSH, *RTECS* (GO5950000), for additional toxicity data. For data on specific isomers, see *RTECS* (GO6125000, *meta*; GO6300000, *ortho*; and GO6475000, *para*).

Section 3. Physical Data

Boiling Point Range: 375.8 to 397.4 °F (191 to 203 °C)
Melting Point Range: 51.8 to 95 °F (11 to 35 °C)
Vapor Pressure: 0.25 (*ortho*), 0.15 (*meta*), 0.11 (*para*) mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 3.72
pH: Saturated solutions are neutral or slightly acidic to litmus
Viscosity: 4.49 to 7.0 cP at 104 °F (40 °C)
Molecular Weight: 108.13
Specific Gravity: 1.030 to 1.038 at 77 °F (25 °C)
Water Solubility: Soluble, 1%
Other Solubilities: Soluble in alcohol, ether, dilute alkalies, glycol and vegetable oils
Refraction Index: 1. 5353 at 75.2 °F (24 °C)
Odor Threshold: Low, 0.012 mg/m³; high, 22 mg/m³

Appearance and Odor: Colorless, yellow, or pinkish liquid turning brown on exposure to air or light with a phenolic odor and pungent taste.

Section 4. Fire and Explosion Data

Flash Point: 178 °F (81.11 °C, *ortho*), 187 °F (86.11 °C, *meta* and *para*), CC	**Autoignition Temperature:** 1110 °F (559 °C, *ortho*), 1038 °F (558 °C, *meta* and *para*)	**LEL:** 1.4% (*ortho*), 1.1% (*meta* and *para*) at 302 °F (150 °C)	**UEL:** None reported

Extinguishing Media: While cresol does not ignite easily, it burns. For small fires, use dry chemical, carbon dioxide (CO_2), water spray, or regular foam. For large fires, use water spray, fog, or regular foam. Do not scatter material with more water than is necessary to put out fire.
Unusual Fire or Explosion Hazards: Container may explode in heat of fire.
Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is ineffective for fires involving cresol. Use clothing the manufacturer recommends specifically for use with cresol. If possible without risk, remove container from fire area. Fight fire from maximum distance. Stay away from ends of tanks. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Cresol is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Cresol reacts with oxidizing materials and causes a temperature and pressure increase with chlorosulfonic acid, nitric acid, and oleum.
Conditions to Avoid: Ignition sources and contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of cresol can produce carbon dioxide (CO_2) and toxic cresol fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(142) and OSHA(164) do not list cresol as a carcinogen. **Summary of Risks:** Cresol is corrosive to eyes, skin, and mucous membranes. Degree of toxicity depends on the cresol concentration involved, amount of surface area exposed, and duration of exposure. Ingestion is corrosive to the digestive tract's mucous membranes and can pose serious problems if not treated promptly. Because cresol has a low vapor pressure, it is not volatile enough under normal conditions to present an inhalation hazard. If heated, vapor inhalation is likely. Severe chemical burns and dermatitis are the main hazards in industry. Note that cresol's *ortho* and *para* isomers (if used individually) are in crystal form and thus are a dust inhalation hazard. By all routes of exposure, cresol produces toxic symptoms similar to phenol's. **Medical Conditions Aggravated by Long-Term Exposure:** Skin diseases. **Target Organs:** Eyes, skin, central nervous system (CNS), liver and kidney. **Primary Entry Routes:** Skin and eye contact/absorption. **Acute Effects:** Cresol is absorbed through skin, open wounds, and the mucous membranes of the respiratory and digestive tracts. The rate at which skin absorbs cresol depends more on the size of exposure area than on the concentration of material applied. Cresol is corrosive to the skin causing smarting; tingling; redness; swelling; burns that may be very painful and become white and wrinkled with softening that may become gangrenous; blisters; possible shock as a result

Continue on next page

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Section 6. Health Hazard Data, *continued*

of pain; and, in severe cases of absorption, coma and death. Contact with eyes may cause stinging, and burning, watering of eyes, redness and swelling of lids, corneal opaqueness causing blurred vision and possible loss of sight. In rare cases, a pigment disorder called ochronosis occurs characterized by darkening of skin, conjunctiva, and cartilage of the nose and ears. Ingestion leads to burning of lips, mouth, and throat, pain in swallowing, ulceration of the mucous membranes of the mouth, color change of the tongue (white), thirst, throat swelling, cramps, nausea and vomiting (sometimes of coffee grounds-like material due to digestive hemorrhage). In severe cases symptoms might progress to shock, convulsions, coma, and death. If vapor inhalation occurs, symptoms include irritation of mucous membranes of nose, eyes, and mouth, watering of eyes, sneezing, coughing, difficulty breathing, headache, nausea, muscle weakness, and possible pulmonary edema. In most cases of exposure, if death occurs, it is usually caused by respiratory failure. **Chronic Effects:** Repeated exposure to cresol may cause digestive disturbances, liver, kidney, spleen and pancreatic damage, and skin eruptions or dermatitis. Some people can become allergic or hypersensitive to cresol.

FIRST AID: *Emergency personnel should protect against contamination.*

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing to prevent burns. Rinse with flooding amounts of water for at least 15 min. If clothing is stuck to skin after flushing with water, *do not* remove! Thoroughly wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting with 2 tablespoons of Ipecac (adult dose). After patient vomits, give activated charcoal in 8 oz. of water to drink. **After first aid, get appropriate in-plant, paramedic, or community medical support.**

Note to Physicians: Since effects may be delayed, keep victim under observation. Irrigate eyes and wash skin with a mixture of polyethylene glycol 300 and industrial methylated spirits (PEG 300/IMS, 2:1 by volume). Recommended treatment for ingestion is repeated gastric lavage with large quantities of olive oil.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area (with fixed or portable fan systems for cross-ventilation), deny entry, and stay upwind. Shut off all ignition sources. Spilled liquid can be neutralized with crushed limestone or soda ash. Take up small spills with earth, sand, vermiculite or other absorbent, noncombustible material and place into suitable containers. For large spills, dike far ahead of liquid for later disposal or reclamation. For water spills, you may need to trap cresol at the bottom with sandbag barriers, apply activated charcoal, and then remove trapped material with dredges or lifts. Follow applicable OSHA regulations (29 CFR 1910.120).

Environmental Degradation: When released into the atmosphere, cresol degrades by reacting with photochemically produced hydroxyl radicals during the day (half-life = 8 to 10 hr), and with nitrate radicals at night (half-life = 2 to 5 min). Cresol biodegrades in eutrophic (nutrient-rich) waters.

Ecotoxicity Values: Blue gill, TL_m, 24 mg/L/96 hr (fresh water); shrimp, TL_m, 10 to 100 ppm/48 hr (saltwater).

Soil Absorption/Mobility: Cresol is mobile in soil but biodegradation is probable. Cresols probably leach due to water solubility.

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U052*
Listed as a CERCLA Hazardous Substance† (40 CFR 302.4): Reportable Quantity (RQ), 1000 lb (454 kg) [† per RCRA, Sec. 3001 and CWA, Sec. 311(b)(4)]
Listed (*o-cresol only*) as a SARA Extremely Hazardous Substance (40 CFR 355)
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

* When a spent solvent and classified as a hazardous waste from nonspecific sources, cresol has Hazardous Waste No. F004.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles or faceshields to protect against droplets or spray, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. At 50 to 500 ppm use a full face gas mask. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. Rubber is suggested as a material suitable for protection against cresol.

Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in properly labelled (with trade name) iron or steel containers in cool, dry, well-ventilated location. Protect from light and keep away from incompatibles (Sec. 5). Outside or detached storage is preferred. To prevent static sparks, electrically ground and bond all equipment used in cresol manufacture, use, and storage.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level.

Administrative Controls: Consider preplacement and periodic examinations of exposed workers that emphasize skin, kidney, liver, and respiratory system.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Cresol
DOT Hazard Class: Corrosive material
ID No.: UN2076
DOT Label: Corrosive
DOT Packaging Exceptions: 173.244
DOT Packaging Requirements: 173.245

IMO Shipping Name: Cresols (*o-*, *m-*, *p-*)
IMO Hazard Class: 6.1
ID No.: UN2076
IMO Label: Poison
IMDG Packaging Group: II

MSDS Collection References: 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 140, 153, 159, 162, 163, 164
Prepared by: M Gannon, BA; Industrial Hygiene Review: PA Roy, MPH, CIH; Medical Review: AC Darlington, MPH, MD; Edited by: JR Stuart, MS

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Material Safety Data Sheet Collection
Methyl *n*-Butyl Ketone MSDS No. 425
Date of Preparation: 10/79 Revision: B, 12/94

Section 1 - Chemical Product and Company Identification 45

Product/Chemical Name: Methyl n-Butyl Ketone
Chemical Formula: $CH_3COC_4H_9$
CAS No.: 591-78-6
Synonyms: butyl methyl ketone, 2-hexanone, hexan-2-one, MBK, MNBK, 2-oxohexane, propylacetone.
Derivation: Produced by reaction of acetyl chloride with butyl magnesium chloride or by catalyzed reaction of acetic acid and ethylene under pressure, followed by distillation.
General Use: Formerly used as a solvent for lacquers, thinners, nitrocellulose, resins, oils, fats, and waxes. Not currently produced in the United States, but potential exposure can occur through its presence as a byproduct in wood pulping, coal gassification, and oil-shale processing.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Methyl *n*-Butyl Ketone, ca % vol

OSHA PELs
8-hr TWA: 100 ppm (410 mg/m^3)
Vacated 1989 Final Rule: 8-hr TWA: 5 ppm (20 mg/m^3)

ACGIH TLV
TWA: 5 ppm (20 mg/m^3)

NIOSH REL
10-hr TWA: 1 ppm (4 mg/m^3), *skin*

IDLH Level
1600 ppm

DFG (Germany) MAK
TWA: 5 ppm (21 mg/m^3)
Category II: Substances with systemic effects
Onset of Effect: ≤ 2 hr
Half-life: < 2 hr

Peak Exposure Limit:
10 ppm, 30 min. average value, 4/shift

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Methyl *n*-butyl ketone exists as a colorless liquid with a pungent, acetone-like odor. It is irritating to the eyes and skin. Inhalation can cause varying degrees of central nervous system depression ranging from nausea and headache to unconsciousness. Chronic exposure through inhalation and skin absorption can lead to significant nerve damage. It is a flammable liquid and capable of forming explosive mixtures with air.

Wilson Risk Scale
R 1
I 3
S 2*
K 3
*Skin absorption

HMIS
H 2*
F 3
R 0
*Chronic effects
PPE†
†Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, eye and skin contact/absorption.
Target Organs: Eyes, skin, respiratory system, central and peripheral nervous systems.
Acute Effects
Inhalation: Vapor inhalation can cause respiratory tract irritation and varying degrees of central nervous system depression. Symptoms include headache, nausea and vomiting, incoordination, and dizziness, with progression to narcosis (unconsciousness) and cardiorespiratory failure.
Eye: Irritation can occur from exposures to as low as 1000 ppm for 15 sec. to 1 min.
Skin: Methyl *n*-butyl ketone is easily absorbed through the skin (222 mg/hr through hands).
Ingestion: Central nervous system depression (see inhalation) is likely.
Carcinogenicity: IARC, NTP, and OSHA do not list methyl *n*-butyl ketone as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: Skin conditions such as dermatitis or any disorder that affects the peripheral nervous system.
Chronic Effects: Repeated skin contact can cause dermatitis. Repeated inhalation or skin absorption can lead to significant peripheral nerve damage due to metabolism to 2,5-hexanedione. Symptoms include muscle weakness, tingling, sensation loss, and incoordination. The degree of these effects vary depending on exposure duration and concentration and may progress slowly for several months after cessation of exposure. In general, chronic exposure appears to affect only the peripheral nervous system; however, some animal studies have demonstrated chronic damage to the central nervous system, including the optic nerves. Whereas peripheral nerves may regenerate after damage, nerves of the central nervous system do not.
Other: MBK toxicity is potentiated by exposure to other solvents, especially those that increase liver microsomal activities.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed.
Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously

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with flooding amounts of water for at least 15 min. Consult a physician or ophthalmologist if pain or irritation persist.

Skin Contact: *Quickly* remove contaminated clothing (*be aware*, clothing is now flammable - dispose of or clean with care). Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.

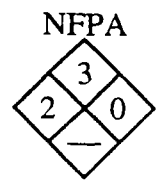
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water. *Do not* induce vomiting if small amounts have been ingested because of the danger of aspiration into the lungs. However, if large amounts are ingested, vomiting may be indicated as potential systemic effects may outweigh danger of aspiration. Consult a physician.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: In chronic exposures, clinical biopsies and electromyographic studies may show axonal degeneration with enlarged axons containing masses of neurofilaments and thinning of the myelin sheath.

Section 5 - Fire-Fighting Measures

Flash Point: 77 °F (25 °C), 83 °F (28.3 °C)
Flash Point Method: CC, OC
Burning Rate: 4.8 mm/min.
Autoignition Temperature: 795 °F (423 °C)
LEL: 1.22% v/v
UEL: 8% v/v



Flammability Classification: Class 1C Flammable Liquid

Extinguishing Media: For small fires, use dry chemical, carbon dioxide, or alcohol-resistant foam. For large fires, use fog or alcohol-resistant foam. Water spray may be ineffective for fires as methyl *n*-butyl ketone may float on top of water and spread fire.

Unusual Fire or Explosion Hazards: Vapors may travel to an ignition source and flash back. Container may explode in heat of fire. Methyl *n*-butyl ketone presents a vapor explosion hazard indoors, outdoors, and in sewers.

Hazardous Combustion Products: Acrid smoke and carbon dioxide gas.

Fire-Fighting Instructions: Apply cooling water to sides of fire-exposed containers until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use unmanned monitor nozzles or unmanned hose holders. If impossible, withdraw from area and let fire burn. Withdraw from area immediately if you hear any rising sound from venting safety device or notice any tank discoloration as a BLEVE (boiling liquid expanding vapor explosion) may be imminent. Do not release runoff from fire control methods to sewers or waterways.

Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. Use water spray to "knock-down" vapor. Cleanup personnel should protect against inhalation and skin/eye contact.

Small Spills: Take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers.

Large Spills

Containment: Dike far ahead of liquid spill for later disposal or reclamation. Do not release into sewers or waterways.

Cleanup: Damp mop any residue.

Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Do not use near heat or ignition sources. Use non-sparking tools to open containers.

Storage Requirements: Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles (sec. 10).

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: To prevent static sparks, electrically ground and bond all equipment used with and around methyl *n*-butyl ketone. Inert atmospheres may be useful for process equipment.

Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103)

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the peripheral nervous system and skin. Advise employees of the health and fire hazards associated with handling methyl *n*-butyl ketone.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For ≤ 10 ppm, use any supplied-air respirator. For ≤ 25 ppm, use any supplied-air respirator operated in continuous-flow mode. For ≤ 50 ppm, use any SAR with a

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tight-fitting facepiece operated in continuous-flow mode or any SCBA or supplied-air respirator with a full facepiece. For ≤ 1600 ppm, use any supplied-air respirator with a full facepiece operated in pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove methyl *n*-butyl ketone from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using methyl *n*-butyl ketone, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Liquid
Appearance and Odor: Colorless with a pungent odor.
Odor Threshold: 0.076 ppm
Vapor Pressure: 11 mm Hg at 77 °F (25 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3, 0.075 lb/ft^3): 1.243 kg/m^3 or 0.077 lb/ft^3
Formula Weight: 100.16
Specific Gravity (H_2O=1, at 4 °C): 0.8113 at 68 °F (20 °C)
Bulk Density: 6.75 lb/gal
Water Solubility: 1.4 wt% at 68 °F (20 °C)
Other Solubilities: Soluble in alcohol, acetone, and ether.
Boiling Point: 268 °F (128 °C)
Freezing Point: -70.6 °F (-57 °C)
Viscosity: 0.62 cP at 68 °F (20 °C)
Refractive Index: 1.4024 at 68 °F (20 °C)
Surface Tension: 25.49 dyne/cm at 68 °F (20 °C)
Relative Evaporation Rate (BuAc = 1): 1
Octanol Water Partition Coefficient: log Kow = 1.38
Ionization Potential: 9.34 eV

Section 10 - Stability and Reactivity

Stability: Methyl *n*-butyl ketone is stable at room temperature in closed containers under normal storage and handling conditions.
Polymerization: Hazardous polymerization does not occur.
Chemical Incompatibilities: Strong oxidizers.
Conditions to Avoid: Exposure to heat, ignition sources, and incompatibles.
Hazardous Decomposition Products: Thermal oxidative decomposition of methyl *n*-butyl ketone can produce carbon dioxide.

Section 11- Toxicological Information

Toxicity Data:*

Skin Effects:
Rabbit, skin: 500 mg/24 hr caused mild irritation.

Acute Dermal Effects:
Rabbit, skin: LD_{50}: 4800 mg/kg

Teratogenicity:
Rat, inhalation: 1000 ppm/6 hr administered from 1 to 21 days of pregnancy caused specific developmental abnormalities of the gastrointestinal and urogenital system.

Acute Inhalation Effects:
Human, inhalation, TC_{Lo}: 1000 ppm caused headache and nausea or vomiting.
Rat, inhalation, LC_{50}: 8000 ppm

Acute Oral Effects:
Rat, oral, LD_{50}: 2590 mg/kg
Guinea pig, oral, LD_{50}: 914 mg/kg

Multiple Dose Toxicity Data:
Chicken, inhalation: 200 ppm/90 days, continuously caused peripheral nerve sensation changes (spastic paralysis with or without sensory change) and weight loss or decreased weight gain.

* See NIOSH, *RTECS* (MP1400000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Fathead minnow (*Pimephales promelas*), LC_{50} = 428 mg/L/96 hr at 77 °F (25 °C)
Environmental Degradation: If released to soil, methyl *n*-butyl ketone is highly mobile and can leach to groundwater. Some may volatilize as well as undergo rapid biodegradation. In water, volatilization is expected to be rapid. Bioconcentration is not expected (BCF = 6). In the air, methyl *n*-butyl ketone reacts with photochemically-produced hydroxyl radicals with an estimated half-life of 2 days. Because it is soluble, washout via rain is expected.
Soil Absorption/Mobility: Highly mobile.

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Section 13 - Disposal Considerations

Disposal: Methyl *n*-butyl ketone can be subjected to incineration; addition of a more flammable solvent may facilitate easier burning. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Ketones, liquid, n.o.s.
Shipping Symbols: –
Hazard Class: 3
ID No.: UN1224
Packing Group: III
Label: Flammable liquid
Special Provisions (172.102): B1, T7, T30

Packaging Authorizations
a) Exceptions: 173.150
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: –

Section 15 - Regulatory Information

EPA Regulations:
Classified as a RCRA Hazardous Waste (40 CFR 261.21): Characteristic of Ignitability, D001
CERCLA Hazardous Substance (40 CFR 302.4) listed per RCRA, Sec. 3001
CERCLA Reportable Quantity (RQ), 100 lb (45.4 kg)
SARA Toxic Chemical (40 CFR 372.65): Not listed
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 73, 103, 124, 136, 149, 167, 176, 189, 192, 197, 200, 201

Prepared By ..... M Gannon, BA
Industrial Hygiene Review ..... S Gilson, CIH
Medical Review ..... WF Boucher, MD

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GENIUM PUBLISHING CORP.

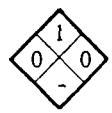
No. 429
DIBUTYL PHTHALATE
(Revision A)

Issued: May 1980
Revised: May 1986

SECTION 1. MATERIAL IDENTIFICATION

21

MATERIAL NAME: DIBUTYL PHTHALATE
OTHER DESIGNATIONS: DBP, Di-n-butyl Phthalate, 1,2-Benzenedicarboxylic Acid DiButyl Ester, C_6H_4 $(COOC_4H_9)_2$, CAS #0084-74-2, ASTM D608.
TRADE NAME/MANUFACTURER:
KODAFLEX DBP, Eastman Chemical Products, Inc., PO Box 431, Kingsport, TN 37662; Telephone: 800-EASTMAN
STAFLEX DBP, Reichhold Chemicals, Inc., 525 North Broadway, White Plains, NY 10603; Telephone: (914) 682-5700
FLEXOL DBP, Union Carbide Corp., Specialty Chemicals Div., Old Ridgebury Rd., Danbury, CT 06817; Telephone: (203) 794-2737



HMIS
H: 0
F: 1
R: 0
PPE*
*See Sect. 8

R 1
I 2
S 1
K 1

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Dibutyl Phthalate, CAS #0084-74-2	> 99	8-hr. TWA: 5 mg/m^3*
		Reproductive Effects: Rat, Oral (7 Days, Male), TDLo: 8400 µg/kg
		Rat, Interperitoneal (5-15 days pregnant),TDLo: 305 mg/kg
* Current OSHA PEL and ACGIH (1985-86) TLV.		Human, Oral, TDLo: 140 mg/kg
		Rat, Oral, LD_{50}: 12 g/kg

SECTION 3. PHYSICAL DATA

Boiling Point, 1 atm ... 644°F (340°C)
Vapor Pressure @ 115°C, mm Hg ... 0.1
Vapor Density (Air = 1) ... 9.6
Solubility in Water @ 20°C, % ... 0.46
Specific Gravity (H_2O = 1) ... 1.05
Viscosity @ 20°C, cp ... 20.3
Freezing Point ... -31°F (-35°C)
Molecular Weight ... 278

Appearance and odor: A clear, colorless, nonvolatile, oily liquid; odorless or with a slight aromatic odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp.	Flammability Limits in Air	LOWER	UPPER
315°F (157°C) CC	757°F (402°C)	Vol. % (at 456°F, [240°C])	0.47	Not Found

EXTINGUISHING MEDIA: Use water spray, dry chemical, CO_2, or foam. Water or foam may cause frothing. Use water to cool fire-exposed containers.
This OSHA class IIIB combustible liquid is a slight fire hazard when exposed to heat or flame.

UNUSUAL FIRE/EXPLOSION HAZARDS: This material reacts explosively with chlorine.

SPECIAL FIRE-FIGHTING PROCEDURES: Fire fighters should use self-contained breathing apparatus.

SECTION 5. REACTIVITY DATA

Dibutyl phthalate is stable. Hazardous polymerization cannot occur.

CHEMICAL INCOMPATIBILITIES: This material is combustible and can react vigorously with oxidizing agents. When heated with chlorine, for example, it can explode. Strongly acidic or alkaline materials can hydrolyze the ester to butyl alcohol and phthalic acid (or its salt).

CONDITIONS TO AVOID: It is incompatible with nitrates, strong oxidizers, strong alkalies, strong acids, and chlorine. Products of hazardous decomposition of DBP include oxides of carbon.

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SECTION 6. HEALTH HAZARD INFORMATION

Dibutyl phthalate is not listed as a carcinogen by the NTP, IARC, or OSHA.

DBP is low in acute oral toxicity, but it has higher toxicity than di-(2-ethylhexyl) phthalate (see Genium MSDS #414). Its low vapor pressure makes it a low inhalation hazard unless it is heated or misted; inhaled vapor or mist can be irritating to the respiratory tract. Liquid contact with the eyes can be irritating and painful, causing tearing. Ingestion of 10g of DBP by a young male adult induced nausea and vertigo. Signs of keratitis and excess albumin and blood cells in the urine were observed; recovery with no aftereffects was reported.

TARGET ORGANS: Respiratory tract, gastrointestinal tract. PRIMARY ENTRY: Inhalation, ingestion, skin. ACUTE EFFECTS: Eye irritation with profuse tearing.

FIRST AID: EYE CONTACT: Flush thoroughly with running water, including under the eyelids, for 15 minutes. Get medical help.* SKIN CONTACT: Wash affected area well with soap and water. Remove contaminated clothing. INHALATION: Remove victim to fresh air. Get medical help if symptoms persist.* INGESTION: Get medical help for treatment, observation, and support.* (If the amount swallowed was large and medical help or advice is unavailable, give victim milk or water to drink and induce vomiting.) Do not give anything by mouth to someone who is unconscious or convulsing.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK: Notify safety personnel of major DBP spills. Provide ventilation. Contain spills and collect material for recovery or disposal. Prevent flushing waste to a sewer or to a watercourse. Pick up small spills and residues with paper or another absorbent solid for disposal. Those involved in cleanup need protection against contact with liquid and vapor or mist inhalation.

DISPOSAL: Burn waste material and scrap in an approved incinerator. Combustibility may be improved by mixing with more flammable solvents such as waste alcohols. Follow Federal, state, and local regulations in disposing of this material.

NOTE: DBP at low chronic concentrations may be detrimental to the reproduction processes of aquatic organisms. It has a moderate biological oxygen demand.

SECTION 8. SPECIAL PROTECTION INFORMATION

Wear chemical safety goggles and rubber or neoprene gloves.

Where vapors are heated or misted, use NIOSH-approved respiratory equipment for nonroutine or emergency situations.

Provide general and local exhaust to meet TLV requirements.

Workers should use additional protection such as aprons or face shields where needed to avoid repeated or prolonged skin contact.

An eyewash station and washing facilities should be available where DBP is handled.

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

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store DBP in closed containers in a cool, dry, well-ventilated area away from acids, bases, and strong oxidizing agents. Protect containers from physical damage.

Because chronic effects are not fully known, practice good hygiene. Wear clean work clothing. Wash hands and face after working with this material and before eating or smoking. Avoid prolonged or repeated contact with DBP. Avoid breathing its mist or vapors.

Those with kidney impairment or disease should not work with this material without a physician's approval and surveillance, because urinary excretion is a major path of elimination of this material.

DOT Classification: ORM-E

Data Source(s) Code: 1-12, 14, 20, 23, 25, 31, 38, 42, 47, 48, 55, 82. CK

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Approvals J.O. Ruocco 1/87.

Indust. Hygiene/Safety 12/86

Medical Review

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GENIUM PUBLISHING CORP.

No. 430
DIMETHYL PHTHALATE
(Revision A)

Issued: May 1980
Revised: February 1987

SECTION 1. MATERIAL IDENTIFICATION

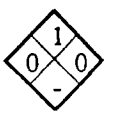
22

MATERIAL NAME: DIMETHYL PHTHALATE

OTHER DESIGNATIONS: DMP; 1,2-Benezenedicarboxylic Acid, Dimethyl Ester; Phthalic Acid, Dimethyl Ester; STAFLEX DMP® (Reichold); $C_6H_4(CH_3OOC)_2$; CAS #0131-11-3

DESCRIPTION/USES: Used as a plasticizer for nitrocellulose, resins, rubber, and solid rocket propellants; used in lacquers, plastics, coating agents, safety glass, molding powders, and insect repellant.

MANUFACTURER/SUPPLIER: Reichold Chemicals, Inc., 525 N. Broadway, White Plains, NY 10603; Telephone: (914) 682-5700
Eastman Chemical Products, Inc., PO Box 431, Kingsport, TN 37662; Telephone: 800-EASTMAN



HMIS			
H	0		
F	1	R	1
R	0	I	2
PPE*		S	1
*See Sect. 8		K	1

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Dimethyl Phthalate, CAS #0131-11-3	100	8-hr. TWA: 5 mg/m^3* Rat, Oral, LD_{50}: 6900 mg/m^3 Rat, Intraperitoneal, 5-15 Days Pregnant, TDLo: 338 mg/kg Mouse, Oral, LD_{50}: 7200 mg/kg

* Current OSHA PEL and ACGIH (1986-87) TLV.

SECTION 3. PHYSICAL DATA

Boiling Point, 1 atm ... 545°F (284°C)
Vapor Pressure, mm Hg @ 20°C ... <0.01
Water Solubility @ 32°C, % ... 0.4
Vapor Density (Air = 1) ... 6.7
Specific Gravity (H_2O = 1) ... 1.19
Viscosity @ 25°C, cp ... 11.0
Melting Point ... 32 to 36°F (0 to 2°C)
Molecular Weight ... 194

Appearance and odor: Clear, colorless, oily liquid; slight ester odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
				Not
295°F (147°C), CC	915°F (490°C)	% by Volume @ 180°C	0.94	Found

EXTINGUISHING MEDIA: Use water spray, dry chemical, carbon dioxide, or foam. Use a water spray to cool fire-exposed containers and surrounding combustibles. This OSHA class IIIB combustible liquid is a slight fire hazard when exposed to heat or flames.

UNUSUAL FIRE/EXPLOSION HAZARDS: Water or foam may cause frothing.

SPECIAL FIRE-FIGHTING PROCEDURES: Fire fighters should use self-contained breathing apparatus and wear fully protective clothing.

SECTION 5. REACTIVITY DATA

Dimethyl phthalate is stable. Hazardous polymerization cannot occur.

This material is incompatible with strong acids or bases, nitrates, and strong oxidizing agents.

Hazardous products of decomposition of dimethyl phthalate are oxides of carbon.

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SECTION 6. HEALTH HAZARD INFORMATION | TLV

Dimethyl phthalate is not listed as a carcinogen by the NTP, IARC, or OSHA.
As determined by studies where animals were subjected to acute exposures of this material, DMP is low in toxicity, but it has the highest acute toxic effects of the dialkyl phthalates. DMP is able to accumulate in body tissues because of its low water solubility and relatively high lipid solubility. As a result, chronic exposure tends to be more important than acute exposure. DMP (mist or liquid) is irritating to the eyes (conjunctivitis) and can cause considerable pain on contact without appreciable injury. Inhalation of mist or fume causes irritation of the respiratory tract and coughing. It is low in skin irritancy. When swallowed, a burning irritation of the lips, tongue, and mouth; vomiting and diarrhea; and possible central nervous system depression can occur. TARGET ORGANS: Respiratory system, gastrointestinal tract. PRIMARY ENTRY: Inhalation, ingestion. ACUTE EFFECTS: Eye and gastrointestinal irritant.
FIRST AID: EYE CONTACT: Flush eyes thoroughly, including under the eyelids, with running water for 15 minutes. Get medical help.* SKIN CONTACT: Remove contaminated clothing. Flush affected area with water; wash with soap and water. Get medical help.* INHALATION: Remove victim to fresh air. Restore and/or support his breathing as required. Get medical help.* INGESTION: Rinse victim's mouth with water. Give him 2 to 3 glasses of water to drink to dilute material. Induce vomiting. Never give anything by mouth to someone who is unconscious or convulsing. Get medical help.*
* *GET MEDICAL ASSISTANCE = In plant, community, paramedic. Get medical help for further treatment, observation, and support after first aid.*

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Notify safety personnel of major dimethyl phthalate leaks. Provide ventilation. Contain spills and collect waste for recovery or disposal. Prevent flushing waste to the sewer or to a watercourse. Pick up small spills and residues for disposal with paper or other absorbent. Those involved with cleanup need protection against contact with liquid and inhalation of mist/vapors.

DISPOSAL: Burn waste material and scrap in an approved incinerator. Combustibility may be improved by mixing with more flammable solvents (example, waste alcohol). Follow Federal, state, and local regulations in disposing of material.

NOTE: Disposal of this material in aquatic systems could lead to possible ecological effects. This material has a high biological oxygen demand.
EPA, Clean Water Act, Reportable Spill Quantity: None Listed.

SECTION 8. SPECIAL PROTECTION INFORMATION

Wear chemical safety goggles where splashing is possible. Wear rubber or neoprene gloves to prevent repeated or prolonged contact of this material with skin.

Where vapors are heated or misted, wear NIOSH-approved respiratory protection for nonroutine or emergency situations. Use a high-efficiency particulate respirator with a full facepiece for levels of exposure up to 250 mg/m^3. Higher levels require a self-contained breathing apparatus with a full facepiece. Provide general and local exhaust to meet TLV requirements.

Workers should wear additional protection such as an apron or face shield where needed to avoid repeated or prolonged skin contact.
Make an eyewash station and washing facilities available where DMP is handled.

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

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store dimethyl phthalate in closed containers in a cool, dry, well-ventilated area away from storing oxidizing agents. Protect containers from physical damage.

Because chronic effects are not fully known, practice good hygiene. Wear clean work clothing. Wash hands and face after working with DMP and before eating or smoking. Avoid prolonged or repeated contact with it. Avoid breathing its mist or vapors. Do not take DMP out of your work area or to your home on your clothing or equipment.

Avoid breathing hot vapors or mist.

Dimethyl phthalate is not designated as a hazardous substance by the EPA.
DOT Classification: Not Listed DOT ID No. Not Listed
Data Source(s) Code: 1-9, 14, 23, 31, 38, 47, 49, 82, 84. CK

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Indust. Hygiene/Safety	DJW 4/87
Medical Review	May 87

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GENIUM PUBLISHING CORP.

No. 435
DIETHYL PHTHALATE
(Revision A)

Issued: July 1980
Revised: February 1987

SECTION 1. MATERIAL IDENTIFICATION

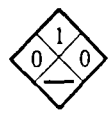
22

MATERIAL NAME: DIETHYL PHTHALATE

DESCRIPTIONS/USES: Used as a solvent for nitrocellulose, a plasticizer, a wetting agent, a camphor substitute, an alcohol denaturant, a mosquito repellant, a plasticizer in solid rocket propellants; and in cellulose acetate, insecticide sprays, plastics, and perfumes.

OTHER DESIGNATIONS: DEP, Ethyl Phthalate, $C_6H_4(CO_2C_2H_5)_2$, CAS # 0084-66-2

MANUFACTURERS:
Ashland Chemical Co., Industrial Chemicals & Solvents Div., Box 2219, Columbus, OH 43216; Telephone: (614) 889-3333
Eastman Chemical Products, Inc., PO Box 431, Kingsport, TN 37662; Telephone: 800-EASTMAN



HMIS
H 0
F 1
R 0
PPE*
*See Sect. 8

R 1
I 2
S 2
K 1

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Diethyl Phthalate, CAS #0084-66-2	>99	8-hr TWA: 5 mg/m^3*
		Human, Inhalation, TCLo: 1000 mg/m^3
		Rat, Intraperitoneal, LD_{50}: 5058 mg/kg
		Rat, Intraperitoneal, 5-15 Days Pregnant, LDLo: 506 mg/kg (Teratogenic Effect)
* Current OSHA PEL and ACGIH (1986-87) TLV.		Rat, Oral, LD_{50}: 9 gm/kg

SECTION 3. PHYSICAL DATA

Boiling Point, 760 mm Hg ... 568°F (298°C)
Viscosity at 25°C, cp ... 9.5
Solubility in Water @ 20°C, g/L ... 0.12
Vapor Pressure @ 163°C, mm Hg... 14
Vapor Density (Air=1) ... 7.66
Specific Gravity 20/20°C ... 1.12
Melting Point ... -40°F (-40°C)
Molecular Weight ... 222.2

Appearance and odor: Clear, colorless liquid. Odorless.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
325°F (163°C), OC	855°F (458°C)	% by Volume, 368°F (187°C)	0.75	Not Found

EXTINGUISHING MEDIA: Use water spray, dry chemical, CO_2, or foam. Water or foam may cause some frothing. Use water to cool fire-exposed containers.

This is an OSHA class IIIB combustible liquid.

SPECIAL FIRE-FIGHTING PROCEDURES: Fire fighters should use self-contained breathing equipment in enclosed areas.

SECTION 5. REACTIVITY DATA

Diethyl phthalate material is stable. Hazardous polymerization cannot occur.

This material is incompatible with strong acids and strong oxidizing agents, nitric acid, permanganates, etc.

Thermal-oxidative degradation can produce toxic vapors and gases, including carbon monoxide, carbon dioxide, and various hydrocarbons.

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SECTION 6. HEALTH HAZARD INFORMATION

Diethyl phthalate is not listed as a carcinogen by the NTP, IARC, or OSHA.
This material is low in toxicity as determined by testing animals at acute exposures but has the second highest acute toxic effects of the dialkyl phthalates. DEP is bioaccumulative in body tissues because of its low water solubility and relatively high lipid solubility. As a result, chronic exposure tends to be more important than acute exposure. Inhalation of hot or heated material causes transient irritation to the nasal and respiratory tract. It will cause skin irritation. It is an eye irritant causing redness and tearing. When swallowed, a burning irritation to the mucous membranes occurs. The vapor at high density acts as a narcotic.
TARGET ORGANS: Respiratory tract, skin. PRIMARY ENTRY: Inhalation. ACUTE EFFECTS: Eye and skin irritation. CHRONIC EFFECTS: Not found.
FIRST AID: EYE CONTACT: Flush eyes thoroughly, including under eyelids, with running water for 15 minutes. SKIN CONTACT: Remove contaminated clothing. Flush affected area with water; wash with soap and water. Get medical help* if a large skin area was contacted or if irritation persists. INHALATION: Remove victim to fresh air. Restore and/or support his breathing as required. Get medical help.* INGESTION: Rinse victim's mouth with water. Give him 2 to 3 glasses of water to drink. Get medical help.* If victim is conscious and alert and medical help is not readily available, induce vomiting.
* GET MEDICAL ASSISTANCE = In plant, community, paramedic. Get medical help for further treatment, observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Notify safety personnel of any major diethyl phthalate spill. Provide ventilation. Contain spills and collect them for recovery or disposal. Prevent flushing the waste to sewers or to watercourses. Pick up small spills and residues with paper or other absorbent for disposal. Those involved with cleanup need protection against contact with liquid and fume or mist inhalation.
DISPOSAL: Burn waste material and scrap in an approved incinerator. Combustibility may be improved by mixing it with more flammable solvents (for example, waste alcohol). Follow Federal, state, and local regulations in disposing of waste material.
NOTE: This material has possible ecological effects in aquatic systems. Because of its stability, DEP can persist in the environment. It has a high biological oxygen demand.
EPA, Hazardous Waste No. W088
EPA, Clean Water Act, Reportable Spill Quantity: Not Listed.

SECTION 8. SPECIAL PROTECTION INFORMATION

Wear chemical safety goggles where splashing can occur.
Wear rubber or neoprene gloves and impervious clothing to prevent repeated or prolonged contact of this material with skin.

A NIOSH-approved respirator may be needed in the absence of proper environmental controls.
Provide general and local exhaust ventilation to meet TLV requirements and/or to control vapor from heated material.

An eyewash station and washing facilities should be available where DEP is handled. If large amounts are used, a safety shower should be available.

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

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store diethyl phthalate in closed containers in a cool, dry, well-ventilated area away from acids, bases, and strong oxidizing agents. Protect containers from physical damage.

Because chronic effects are not fully known, practice good hygiene. Wear clean work clothing. Wash hands and face after working with this material and before eating or smoking. Avoid prolonged or repeated contact with it. Avoid breathing its mist or vapors. Containers of this material may be hazardous when emptied because of retained product residues.

Diethyl phthalate is not designated as a hazardous substance by the EPA.
DOT Classification: Not Listed DOT UN No. Not Listed
Data Source(s) Code: 1, 2, 4-12, 14, 20, 23, 47, 48, 82, 84. CK

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Indust. Hygiene/Safety 4/87
Medical Review May 87

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GENIUM PUBLISHING CORP.

No. 439

NITROBENZENE
(Revision A)
Issued: July 1980
Revised: April 1989

SECTION 1. MATERIAL IDENTIFICATION •28

Material: NITROBENZENE

Description (Origin/Uses): Prepared by treating benzene with a mixture of nitric acid (HNO_3) and sulfuric acid (H_2SO_4). Used as an intermediate in the manufacture of aniline and benzidine; also used in some shoe and metal polishes.

NFPA

Other Designations: Nitrobenzol; Essence of Mirbane; Oil of Mirbane; $C_6H_5NO_2$; CAS No. 0098-95-3

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

Comments: Simultaneous exposure to ethanol aggravates the poisonous effects of exposure to nitrobenzene. Workers must not drink alcoholic beverages before or after their shifts.

HMIS	
H 3	I 4
F 2	S 2†
R 0	K 2
PPG*	†Absorption
*See sect. 8	risk is high

SECTION 2. INGREDIENTS AND OCCUPATIONAL EXPOSURE LIMITS

Nitrobenzene, ca 100%

OSHA PEL (Skin*)
8-hr TWA: 1 ppm, 5 mg/m³

ACGIH TLV (Skin*), 1988-89
TLV-TWA: 1 ppm, 5 mg/m³

Toxicity Data†
Woman, Oral, TD_{Lo}: 200 mg/kg
Rat, Oral, LD_{50}: 640 mg/kg

*This material can be absorbed through intact skin, which contributes to overall exposure.
†See NIOSH, *RTECS* (DA6475000), for additional data with references to irritative, reproductive, and mutagenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 410 °F (210 °C)
Melting Point: 42.8 °F (6 °C)
Vapor Density (Air = 1): 4.25
Vapor Pressure: <1 Torr
Molecular Weight: 123 g/mol
Solubility in Water (%): Slight
Specific Gravity (H_2O = 1): 1.205 at 59 °F (15 °C)
Appearance and Odor: A colorless to pale yellow oily liquid or bright yellow solid crystals; a distinctive odor of volatile almond oil. Its identification threshold is 4.7 parts per billion (ppb).

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point: 190 °F (88 °C) CC	Autoignition Temperature: 900 °F (482 °C)	LEL: 1.8% v/v	UEL: Not Found

Extinguishing Media: Use dry chemical, "alcohol" foam, carbon dioxide (CO_2), or a water spray to put out fires involving nitrobenzene. Water spray can be used to disperse vapor, to cool fire-exposed containers, and to flush nonignited spills or vapor away from sensitive exposures such as incompatible chemicals or sources of ignition. **Unusual Fire or Explosion Hazards:** Nitrobenzene vapor is more than 4 times heavier than air (see sect. 3); it can flow along surfaces, collect in low-lying, confined areas, reach a distant source of ignition, and flash back to its source. This vapor can easily form an explosive mixture with air, especially if the nitrobenzene is heated (heating will cause more nitrobenzene vapor to be given off). **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 5. REACTIVITY DATA

Stability/Polymerization: Nitrobenzene is stable in closed containers during routine operations at room temperature. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Nitrobenzene is an oxidizing agent that can react dangerously with reducing agents such as nitric acid (HNO_3); phenol (C_6H_5OH) and aluminum chloride ($AlCl_3$); aniline and glycerine; silver perchlorate ($AgClO_4$); dinitrogen tetroxide (N_2O_4); caustics; and reactive metals such as tin or zinc. **Conditions to Avoid:** Prevent exposure to sources of heat and ignition or to incompatible chemicals. **Hazardous Products of Decomposition:** Thermal oxidative degradation of nitrobenzene can produce toxic gases such as carbon monoxide (CO) and oxides of nitrogen (NO_x).

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: Nitrobenzene is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: Nitrobenzene is a deadly poison that can be rapidly absorbed through intact skin. It reacts with hemoglobin in the blood to form methemoglobin, which seriously depletes the blood's oxygen-carrying capacity. The onset of even potentially fatal methemoglobinemia is insidious; severe symptoms can be delayed for up to 4 hours. The exposed person may feel well and have no complaints; he or she may exhibit signs of cyanosis such as blue lips, nose, and ears, which are noticeable but not uncomfortable; headache is commonly the first symptom of intoxication and may become more intense as the condition progresses. Workers can be exposed to dangerous levels of this poison without immediately discernible health effects. Cyanosis, anemia, and deleterious effects on the central nervous system (CNS) and the cardiovascular system (CVS) can develop following significant occupational exposure to nitrobenzene. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of the heart, liver, and blood. **Target Organs:** Skin, eyes, blood, liver, kidneys, testicles, and CVS. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** Symptoms of occupational exposure to nitrobenzene include headache, vertigo, vomiting, nausea, dizziness, anemia, atoxia, shortness of breath, rapid pulse, and irritation of the skin and eyes. Coma and death may ensue. **Chronic Effects:** Chronic exposure produces a reversible anemia. *(cont'd.)*

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SECTION 6. HEALTH HAZARD INFORMATION, continued

FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. **Skin.** Completely remove nitrobenzene from the exposed person's body. Immediately remove all clothing and wash the entire body from head to foot with soap and water. Pay special attention to the ear canals, fingernails, toenails, hair, and scalp because they are sources of continuing absorption of this poison. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen to alleviate the headache and general sense of weakness that characterize nitrobenzene intoxication. Keep exposed person warm and at rest until medical help is available. **Ingestion.** Unlikely. If accidental ingestion should occur, have the exposed person drink 1 to 2 glasses of water, then induce vomiting. **Comments:** Do not expose workers with existing heart, liver, or blood disorders to nitrobenzene. Screen prospective employees by testing them for hypersensitivity to hemolytic chemicals such as nitrobenzene. Alcohol ingestion and a heated environment may increase susceptibility. Instruct employees on methemoglobinemia signs and symptoms. **Get in-plant, paramedic, or community medical help for all exposures.** Seek prompt medical assistance for further treatment and support after first aid. **Physician's Note:** Determine the methemoglobin concentration in the blood; repeat this test hourly for at least 24 hr until a definite decline is noted. Repeat thorough skin cleaning if the methemoglobin level rises after 3 or 4 hr. Patients usually return to normal within 24 to 48 hr if all absorption sources are eliminated. Administer oxygen, using intermittent positive-pressure breathing (IPPB) if its available.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: *Treat accidental bulk releases of nitrobenzene as emergencies.* Prior planning and designing of emergency response routines are necessary. Notify safety personnel, evacuate nonessential personnel, eliminate sources of heat and ignition, and provide adequate explosion-proof ventilation, particularly at floor level (see sect. 4). Cleanup personnel must wear a complete set of personal protective equipment (see sect. 8) to protect the skin and eyes against any contact with this liquid poison or inhalation of its vapor. Shovel, scoop, or vacuum the released nitrobenzene and place it into appropriate containers for disposal. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z)

EPA Designations

Listed as RCRA Hazardous Waste No. U169 (40 CFR 261.33)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [*per CWA, §311(b)(4) and 307(a); and RCRA, §3001]

Listed as a SARA Extremely Hazardous Substance (40 CFR 355), Threshold Planning Quantity (TPQ): 10000 lb

Listed as a SARA Toxic Chemical* (40 CFR 372.65) [*EPA Form R may apply to your facility; see 40 CFR 372.85 for instructions]

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of nitrobenzene is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Wear a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (leaks or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets to prevent any contact of nitrobenzene with your skin. **Ventilation:** Install and operate general and local maximum-explosion-proof ventilation systems powerful enough to maintain airborne concentrations of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work 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 your shoes and equipment. **Comments:** The health effects of nitrobenzene are so dangerous that persons exposed to it should be periodically instructed in safe-handling procedures and in recognizing the symptoms of developing cyanosis (see sect. 6). Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off 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 work areas. Avoid all skin contact with this liquid and inhalation of its vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store nitrobenzene in closed containers in a cool, dry, well-ventilated, low fire-risk area away from incompatible chemicals (see sect. 5) and sources of heat or ignition. Protect these containers from physical damage; shield them from direct sunlight. **Engineering Controls:** Electrically ground and bond all containers and equipment used in shipping, receiving, or sampling operations in production or storage areas to prevent static sparks.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Nitrobenzene, Liquid
DOT Hazard Class: Poison B
DOT ID No.: UN1662
DOT Label: Poison
DOT Packaging Requirements: 49 CFR 173.346
DOT Packaging Exceptions: 49 CFR 173.345

IMO Shipping Name: Nitrobenzene
IMO Hazard Class: 6.1
IMO Label: Poison
IMDG Packaging Group: II

References: 1, 6, 26, 38, 84-94, 100, 116, 118, 119, 122

Prepared by: PJ Igoe, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 449
Acrylic Acid

Issued: 3/81 Revision: A, 8/89

Section 1. Material Identification

29

Acrylic Acid Description: Prepared by the air oxidation of acrolein in a two-stage process: 1) propylene to acrolein, and 2) acrolein to acrylic acid. An alternative production method is to hydrolyze acrylonitrile. Used in the manufacture of acrylic resins, especially the acrylates; in polymeric emulsions as coatings for leather, paints, polishes, and adhesives.
Other Designations: 2-Propenoic acid; acroleic acid; propenoic acid; vinyl formic acid; $C_3H_4O_2$; CAS No. 0079-10-7.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide* (Genium ref. 73) for a suppliers list.

R 1
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K 2

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HMIS
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PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Acrylic acid, ca 100%

OSHA PEL (Skin*)	ACGIH TLV (Skin*), 1988-89	NIOSH REL	Toxicity Data†
8-hr TWA: 10 ppm, 30 mg/m³	TLV-TWA: 10 ppm, 30 mg/m³	None established	Rat, oral, LD_{50}: 340 mg/kg Rat, inhalation, LC_{Lo}: 4000 ppm/4 hr

* This material can be absorbed through intact skin, which contributes to overall exposure.
† See NIOSH, *RTECS* (AS4375000), for additional data with references to reproductive and irritative effects.

Section 3. Physical Data

Boiling Point: 286 °F (141 °C)
Melting Point: 55 °F (13 °C)
Vapor Pressure: 31 torr at 77 °F (25 °C)
Vapor Density (Air = 1): 2.5
Molecular Weight: 72 g/mol
Water Solubility: Miscible
pH: <7 (Acidic)

Appearance and Odor: A colorless, corrosive liquid; a distinctive, acrid odor.

Section 4. Fire and Explosion Data

Flash Point: 122 °F (50 °C) TCC*	Autoignition Temperature: 774 °F (412 °C)	LEL: 2.9% v/v	UEL: 8% v/v

Extinguishing Media: Use dry chemical, carbon dioxide (CO_2), foams, or water sprays to put out acrylic acid fires. Fight these fires from a safe, protected, or isolated location. Use water sprays to cool fire-exposed containers, flush spills away from sensitive exposures (heat and ignition sources or incompatible chemicals), and protect personnel attempting to remove uninvolved containers of acrylic acid from the incident area. **Unusual Fire or Explosion Hazards:** Acrylic acid's high vapor pressure and density (Sec. 3) enable its vapors to form quickly, flow along surfaces, collect in low-lying areas, reach distant ignition sources, and flash back to the original liquid. The heat from fires can cause violent polymerization of the acrylic acid with dangerous container rupturing. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.
* 129 °F (54 °C) TOC.

Section 5. Reactivity Data

Stability/Polymerization: Excessive heat may cause violent polymerization of the acrylic acid. This can rupture the container and eject hot polymer from the polymerization site. Commercial acrylic acid is inhibited with methyl ether of hydroquinone (MEHQ) to prolong the usable shelf life, i.e., the time before spontaneous polymerization of the acrylic acid occurs. Since excessive heat or a lack of oxygen can prevent MEHQ from inhibiting the acrylic acid, unexpected polymerization can occur. Contamination, heat, low-oxygen atmosphere, or improper addition of the MEHQ inhibitor can cause spontaneous, violent polymerization of the acrylic acid. **Chemical Incompatibilities:** Acrylic acid is a reactive monomer. Genium reference 84 reports that it can react dangerously with 2-aminoethanol, ammonium hydroxide, chlorosulfonic acid, ethylenediamine, and oleum. **Conditions to Avoid:** Prevent exposure to oxidizing agents, incompatible chemicals, polymerization catalysts, heat, or ignition sources. **Hazardous Products of Decomposition:** Thermal oxidative degradation of acrylic acid can produce carbon monoxide (CO).

Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists arylic acid as a carcinogen.
Summary of Risks: Inhalation of acrylic acid mist or vapor can cause irritation of the nose, eyes, and respiratory system; coughing, difficult breathing, and other respiratory stresses. Acrylic acid absorbed through unbroken skin can cause systemic illness with nausea, vomiting, and gastrointestinal discomfort. Eye contact with the liquid may cause severe corneal damage and blindness. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** Skin contact with acrylic acid can cause irritation, redness, inflammation, and, in certain individuals, sensitization reactions and skin rashes. **Chronic Effects:** None reported.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min. All eye

Continue on next page

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Section 6. Health Hazard Data (continued)

exposures should receive further medical evaluation. **Skin:** After rinsing affected area with flooding amounts of water, wash it with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. Have qualified medical personnel administer oxygen as required. **Ingestion:** Unlikely. If ingested, have the exposed person drink 1 to 2 glasses of water.
After first aid, get appropriate in-plant, paramedic, or community medical attention and support.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice an acrylic acid spill control and countermeasure plan (SCCP).* When a spill occurs, notify safety personnel, limit access to the incident area, provide optimum explosion-proof ventilation, and implement the SCCP. Cleanup personnel must be aware of the serious contamination dangers. Alert the fire-response or crisis management team in the event of bulk releases of acrylic acid. Stabilizing the released material to prevent violent, uncontrolled polymerization of bulk acrylic acid is the primary concern. Never return contaminated liquid to storage (polymerization hazard). Cleanup personnel must wear personal protective equipment (Sec. 8) to prevent skin contact or inhalation. Use only nonsparking tools and equipment. Absorb the spilled liquid with vermiculite, clay, etc., and place it in appropriate disposal containers. **Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Subpart Z)

EPA Designations

Listed as RCRA Hazardous Waste No. U008 (40 CFR 261.33)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical* (40 CFR 372.65): [* EPA Form R may apply to your facility; see 40 CFR for instructions]

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Wear a NIOSH-approved respirator if necessary. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. **Ventilation:** Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL standard (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by eliminating it at its source (Genium ref. 103). **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Launder contaminated clothing before wearing. Remove this material from your shoes and equipment. **Other:** Thaw frozen containers carefully; check with your supplier for details. Never withdraw any material from a partially thawed container. Such material may be uninhibited or may contain most of the MEHQ inhibitor for the entire drum of acrylic acid. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store acrylic acid in closed, monitored containers in a cool, dry, well-ventilated area away from heat or ignition sources, incompatible chemicals (Sec. 5), and polymerization promoters/accelerators/catalysts. Protect these containers from physical damage; shield them from direct sunlight. Take all necessary measures to ensure that the acrylic acid remains contaminant free. Remove from bulk containers only enough acrylic acid to satisfy immediate job requirements. Correlate purchases of this material with batch sizes. Never store it for more than one year. **Special Handling/Storage:** *Acrylic acid corrodes carbon steel.* Build bulk storage containers with stainless steel type 304 or 316. **Caution:** *Never use steam or electrical heating systems for outside storage tanks. Never store under an inert nitrogen gas blanket! Without oxygen, the added inhibitor is ineffective and violent vinyl polymerization can occur.* Maintain at least 10% void volume above the acrylic acid. Ensure contact with air or a 50/50 nitrogen/air mixture. The atmosphere above the acrylic acid should contain at least 5% to 21% oxygen by volume. **Engineering Controls:** Certain impurities such as peroxides and free-radical-forming compounds (aldehydes, azides, ethers) can promote polymerization of acrylic acid. Do not contaminate the acrylic acid monomer with the polymerizing acrylic acid that may be present in localized or hot stagnant areas such as dead-headed pumps, heated transfer lines, etc. Acrylic acid vapors are uninhibited and can form polymers in storage tanks, vents, or flame arrestors. Inspect these vents to prevent blockage. **Other Precautions:** Never let the acrylic acid freeze, especially in outside or unheated storage areas. These storage facilities should be insulated. Use tempered water as a temperature control agent. *Thawing frozen acrylic acid can be extremely hazardous.* When freezing occurs in bulk containers, the first crystals form along the outer container wall. Never thaw the acrylic acid by applying heat directly to the outside of the container since the frozen monomer crystals, which now contain little or no inhibitor, can easily undergo violent, self-accelerating polymerization. Maintain the temperature of this monomer between 59 °F (15 °C) and 77 °F (25 °C) in all storage containers and pipelines. The upper temperature limit is to retard dimer (more complex molecule) formation.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Acrylic acid
DOT Hazard Class: Corrosive material
DOT ID No. : UN2218
DOT Label: Corrosive
DOT Packaging Requirements: 49 CFR 173.245
DOT Packaging Exceptions: 49 CFR 173.244

IMO Shipping Name: Acrylic acid , inhibited
IMO Hazard Class: 8
IMO Label: Corrosive and flammable liquid
IMDG Packaging Group: II

MSDS Collection **References:** 1, 6, 7, 84-94, 100, 116, 117, 119, 120, 122
Prepared by: PJ Igoe, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD M8

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Material Safety Data Sheets Collection:

Sheet No. 509
Vinyl Acetate Monomer

Issued: 2/83 Revision: B, 9/92

Section 1. Material Identification

Vinyl Acetate Monomer ($CH_3COOCHCH_2$) Description: Derived by reaction of glacial acetic acid and acetylene at 40 to 122 °F (50 °C) in the presence of a mercury salt, or more commonly, by vapor-phase reaction of ethylene, acetic acid, and oxygen with a palladium catalyst. Used as a raw material in polyvinyl resin manufacture and in the production of emulsion paint substances, finishing and impregnation materials, and in glue.

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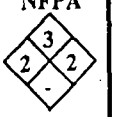
NFPA



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Other Designations: CAS No. 108-05-4, acetic acid, ethenyl ester; 1-acetoxyethylene; ethenyl acetate; ethenyl ethanoate; VAM; vinyl A monomer; VyAc; Zeset-T.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Vinyl acetate is irritating to the eyes, skin, and respiratory tract and causes central nervous system (CNS) depression in high concentrations. It is a highly flammable liquid and can self-polymerize.

Section 2. Ingredients and Occupational Exposure Limits

Vinyl Acetate Monomer, ca 100%. Acetaldehyde is normally present as a result of hydrolysis of vinyl acetate. May be inhibited with 3 to 17 ppm of hydroquinone or up to 200 ppm of diphenylamine if long-term storage is desired.

1991 OSHA PELs
8-hr TWA: 10 ppm (30 mg/m³)
15-min STEL: 20 ppm (60 mg/m³)

1990 NIOSH REL
Ceiling: 4 ppm (15 mg/m³)

1992-93 ACGIH TLVs*
TWA: 10 ppm (35 mg/m³)
STEL: 20 ppm (70 mg/m³)

1990 DFG (Germany) MAK
TWA: 10 ppm (35 mg/m³)
Category I: local irritants
Peak Exposure Limit: 20 ppm,
5 min momentary value, 8/shift

1985-86 Toxicity Data†
Human, eye: exposure to 22 ppm caused irritation.
Human, lymphocyte: 100 µmol/L caused sister chromatid exchange.
Rat, oral, LD_{50}: 2920 mg/kg; toxic effects not yet reviewed
Rat, inhalation, LC_{50}: 4000 ppm/2 hr; toxic effects not yet reviewed

* Notice of intended change in the STEL to 15 ppm (53 mg/m³), Class A2 "suspected human carcinogen".
†See NIOSH, *RTECS* (AK0875000), for additional irritation, mutation, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 163.4 °F (73 °C)
Melting Point: -135 to -148 °F (-93 to -100 °C)
Viscosity: 0.43 cP at 68 °F (20 °C)
Refraction Index: 1.3941 at 68 °F (20 °C)
Bulk Density: 7.79 lb/Gal
Odor Threshold: 0.12 to 0.4 ppm*
Molecular Weight: 86.10

Specific Gravity: 0.932 at 68 °F (20 °C)
Vapor Pressure: 88 mm Hg at 68 °F (20 °C); 115 mm Hg at 77 °F (25 °C)
Saturated Vapor Density (Air = 0.075 lb/ft³ or 1.2 kg/m³): 0.0927 lb/ft³ or 1.483 kg/m³
Water Solubility: Slightly, 1g/50 mL at 68 °F (20 °C)
Other Solubilities: Soluble in acetone, alcohol, benzene, chloroform, ether, ethyl ether, and most organic solvents.

Appearance and Odor: Colorless, mobile liquid with a fruity odor. It polymerizes on exposure to light to a colorless, transparent mass.
* 20 ppm generally produces olfactory fatigue.

Section 4. Fire and Explosion Data

Flash Point: 18 °F (-8 °C) CC; 23 °F (-5 °C) OC	Autoignition Temperature: 756 °F (402 °C)	LEL: 2.6% v/v	UEL: 13.4% v/v

Extinguishing Media: For small fires, use dry chemical, carbon dioxide, 'alcohol-resistant' foam, or water spray. For large fires, use fog, 'alcohol-resistant' foam, or water spray. Be aware that water spray may be ineffective since vinyl acetate floats on water as a slick.

Unusual Fire or Explosion Hazards: Vapors may travel to ignition source and flash back. Container may explode in heat of fire. Vinyl acetate poses a vapor explosion hazard indoors, outdoors, and in sewers. Uninhibited monomer vapor may polymerize in vents and other closed spaces.

Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection. Apply cooling water to sides of containers until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzle or unmanned hose holder; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case you hear a rising safety device or notice any tank discoloration due to fire as a boiling liquid expanding vapor explosion (BLEVE) may be imminent. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Vinyl acetate can self-polymerize due to autoxidation of acetaldehyde (a normal impurity formed by hydrolysis of the monomer) to a peroxide which initiates exothermic polymerization as it decomposes. In bulk, this can accelerate to a dangerous extent. Polymerization can also be initiated by exposure to heat, sunlight, peroxides, and oxidizers. **Chemical Incompatibilities:** Reacts with hydrogen peroxide to form explosive peracetic acid; forms unstable, explosive peroxide with oxygen above 50 °C; and reacts with ozone to form explosive vinyl acetate ozonide. Also incompatible with silica gel, alumina, dibenzol peroxide + ethyl acetate, oxygen, toluene, 2-amino ethanol, chlorosulfonic acid, ethylene diamine, ethylene imine, oleum, hydrochloric acid, hydrofluoric acid, sulfuric acid, and nitric acid. **Conditions to Avoid:** Exposure to heat, sunlight, or incompatibles. Never allow inhibitor to decrease to unsafe levels. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of vinyl acetate can produce acrid smoke and fumes.

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Section 6. Health Hazard Data

Carcinogenicity: The NTP,[169] and OSHA[164] do not list vinyl acetate as a carcinogen. IARC[164] lists vinyl acetate as *Class 3, unclassifiable* and ACGIH as *Class A2, suspected human carcinogen.* There is one known study showing an increased rate of uterine adenocarcinomas in rats. Unfortunately the test group was considered too small for results to be considered conclusive. Other animal studies have not shown any evidence of increased tumors. One study of workers in a U.S. chemical plant failed to find any association between exposure to vinyl acetate and increased lung cancer risk. **Summary of Risks:** Vinyl acetate vapors are irritating to the eyes, skin, and respiratory tract. Vapor inhalation of high concentrations can be narcotic. Chronic exposure may result in respiratory, cardiac, CNS and liver problems. Vinyl acetate appears to metabolize to acetic acid and acetaldehyde in the body. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Eyes, skin, respiratory tract, CNS, cardiovascular system, liver. **Primary Entry Routes:** Inhalation, skin/eye contact, ingestion. **Acute Effects:** Vapor inhalation is irritating to the respiratory tract at ~20 ppm causing cough and hoarseness. Olfactory fatigue will also occur around 20 ppm. If spilled on clothing and allowed to remain, the liquid can cause severe irritation, redness, and blistering. Corneal injury (with recovery) can occur from splashes of the liquid to the eye. **Chronic Effects:** Include chronic bronchitis, CNS symptoms such as fatigue, irritability, insomnia, encephalopathy, vertigo, weakness, and polyneuritis; cardiovascular symptoms such as arrythmias, chest pain, and syncope; liver function changes and hepatic enzyme induction.

FIRST AID

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of aspiration hazard. Gastric lavage may be indicated if large amounts are swallowed and if performed soon after ingestion. **Note to Physicians:** Treatment is symptomatic ans supportive. If victim has ingested large amounts, monitor for CNS depression, respiratory irritation and cardiac arrythmias.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against inhalation and skin/eye contact. Use water spray to disperse vapors. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. Dike far ahead of large spills for later disposal or reclamation. Follow applicable OSHA regulations (29 CFR 1910.120). Report any release > 5000 lb. **Ecotoxicity Values:** Fathead minnow, TLm = 39 to 19 mg/L, 24 to 96 hr; Bluegill, TLm = 18 mg/L, 24 to 96 hr. **Environmental Degradation:** In the atmosphere, vinyl acetate is not likely to undergo photooxidation but can produce ozone in the presence of nitrogen oxides. In water, degradation appears faster in freshwater than seawater. Both on land and in soil, sunlight causes vinyl acetate to polymerize and increases resistance to biodegradation. **Disposal:** Vinyl acetate can be removed from waste gases with activated carbon. Investigate bacterial biodegradation as a means of removal from liquid or solid waste. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a SARA Extremely Hazardous Substance (40 CFR 355), TPQ: 1000 lb
Listed as a RCRA Hazardous Waste (40 CFR 261.21): No. D001, 'Characteristic of ignitability'
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 5000 lb (2270 kg) [* per CWA Sec. 311 (b)(4)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Nitrile, neoprene, Viton, or chlorinated polyethylene are suitable materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area away from sunlight, heat, ignition sources, oxidizing agents, and incompatibles (sec. 5). *Do not* store for longer than 6 months because of vinyl acetate's tendency to self-polymerize over time. Outside or detached storage is preferred. If inside, store in a standard flammable liquids cabinet. Check inhibitor levels regularly. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Regularly check valves and pump seals since vinyl acetate can escape. Install Class 1, Group D electrical equipment. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, cardiovascular system, and liver function.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Vinyl acetate monomer
DOT Hazard Class: 3
ID No.: UN1301
DOT Packing Group: II
DOT Label: Flammable Liquid
Special Provisions (172.102): T8

Packaging Authorizations
a) Exceptions: 173.150
b) Non-bulk Packaging: 173.202
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60 L

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: —

MSDS Collection **References:** 73, 89, 100, 103, 124, 126, 127, 132, 136, 139, 140, 153, 159, 163, 164, 167, 168, 171, 174, 175, 180
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, CIH, MPH; **Medical Review:** AC Darlington, MD, MPH

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Material Safety Data Sheets Collection:

Sheet No. 514
p-Dichlorobenzene

Issued: 10/83 Revision: A, 11/90

Section 1. Material Identification

33

p-Dichlorobenzene ($C_6H_4Cl_2$) **Description:** Derived by chlorinating monochlorobenzene. Used as a general insecticide; a moth repellent; a germicide; a chemical intermediate in the production of polyphenylene sulfide; a plastic used in the electrical and electronics industries; a space deodorant in products such as room deodorizers, urinal and toilet bowl blocks, and diaper pail deodorizers; and in producing 1,2,4 trichlorobenzene.

Other Designations: CAS No. 0106-46-7, 1,4-dichlorobenzene, dichlorocide, Evola,® NCI-c 54955, Paracide,® Paracrystals, Paradi,® paradichlorobenzol, Paramoth,® *p*-chlorophenyl chloride, PDB,® Santochlor.®

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

Cautions: *p*-Dichlorobenzene vapor is an eye and upper respiratory tract irritant. *It is toxic to the liver.* Prolonged exposure to high concentrations may cause weakness, dizziness, and weight loss. Flammable when exposed to heat, flame, or oxidizers.

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PPG*	

* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

p-Dichlorobenzene, ca 100%

1989 OSHA PELs	1990-91 ACGIH TLVs	1988 NIOSH REL	1985-86 Toxicity Data*
8-hr TWA: 75 ppm, 450 mg/m³	TWA: 75 ppm, 451 mg/m³	None established	Human, oral, TD_{Lo}: 300 mg/kg produced sense organs and special senses (other eye effects); lungs, thorax, or respiration (other changes); and gastrointestinal (hypermotility, diarrhea) effects
15-min STEL: 110 ppm, 675 mg/m³	STEL: 110 ppm, 661 mg/m³		Human, eye: 80 ppm

1987 IDLH Level
1000 ppm

* See NIOSH, *RTECS* (CZ4550000), for additional irritative, mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 345 °F (174 °C) at 760 mm Hg
Melting Point: 127.6 °F (53.1 °C)
Vapor Pressure: 10 mm Hg at 130.6 °F (54.8 °C)
Vapor Density (Air = 1): 5.08
Molecular Weight: 147.01
Specific Gravity: 1.248 at 131 °F (55 °C)
Water Solubility: Insoluble

Appearance and Odor: Volatile, white crystals with a distinctive mothball-like odor that becomes very strong at concentrations between 30 and 60 ppm. At concentrations of 80 to 160 ppm, vapors are painful to the eyes and nose. Odors and irritating effects are good warnings against overexposure to *p*-dichlorobenzene; however, individuals may develop tolerance to high concentrations.

Section 4. Fire and Explosion Data

Flash Point: 150 °F (66 °C), CC	Autoignition Temperature: None reported	LEL: 1.7% v/v	UEL: None reported

Extinguishing Media: Use dry chemical, carbon dioxide, alcohol foam, or water spray. Use water spray to cool fire-exposed container, to disperse vapors, or to blanket a pool fire.

Unusual Fire or Explosion Hazards: Explosive and toxic mixtures may form in air when this material is heated, such as in a fire.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective clothing. Thoroughly decontaminate firefighting equipment after use. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: *p*-Dichlorobenzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: *p*-Dichlorobenzene is incompatible with strong oxidizers and oxidizing agents.

Conditions to Avoid: Avoid incompatibilities and heat or ignition sources.

Hazardous Products of Decomposition: Thermal oxidative decomposition of *p*-dichlorobenzene includes carbon monoxide, chlorides, and chlorine.

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Section 6. Health Hazard Data

Carcinogenicity: *p*-Dichlorobenzene is an NTP anticipated human carcinogen and an IARC possible human carcinogen (Group 2B) with inadequate human evidence and sufficient animal evidence.
Summary of Risks: This material has a relatively low level of acute or chronic toxicity. It may be irritating to eyes, nose, upper airways, and intestinal tract upon inhalation or ingestion. Limited case reports link acute exposure to hemolytic anemia, jaundice, methemglobinemia, granulomas of the lung, liver atrophy, toxic hepatitis, kidney injury, and allergic pigmentation and purpura (tiny hemorrhages) of the skin. Occupational studies of PDB-exposed workers reveal none of the blood abnormalities noted with similar substances. Vapors may produce painful irritation of the eyes at 50 to 80 ppm and severe discomfort at 160 ppm.
Medical Conditions Aggravated by Long-Term Exposure: Individuals with liver disease should not be exposed to *p*-dichlorobenzene.
Target Organs: Liver, respiratory system, eyes, kidneys, and skin.
Primary Entry Routes: Inhalation and dermal contact.
Acute Effects: Acute exposures to PDB vapor may be irritating to mucous membranes of the eyes and upper respiratory tract. Ingestion of the solid resulted in toxicity to a 3-year old child, with hemolytic anemia, jaundice, and methemglobinemia. Nausea, vomiting, and diarrhea are seen in other cases. Prolonged skin exposure may cause skin irritation.
Chronic Effects: Limited case studies show chronic toxicity with exposure to PDB. Chronic ingestion is linked to anemia, leukemia, and kidney damage. In one case, chemical dependence was noted with signs of withdrawal when ingestion stopped. Chronic vapor exposure is suggested in cases of lung granulomatosis, liver abnormalities, kidney damage, anemia, other blood cell abnormalities, and cataract formation.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water, then induce vomiting. Consult a physician.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Urinary excretion of 2,5-dichlorophenol, a metabolite of *p*-dichlorobenzene, may be useful as an index of exposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, and remove or extinguish all heat and ignition sources. Cleanup personnel should protect against vapor inhalation and skin or eye contact. For liquid spills, take up spilled material with noncombustible absorbent material and place into clean metal containers for disposal. For large liquid spills, dike far ahead of spill to contain liquid. For dry spills, shovel spilled material into clean metal containers for disposal. Runoff to sewers or waterways may create health and explosion hazards. (96-hr LC_{50}, fathead minnow: 4.2 to 30 mg/l, moderately toxic.) Pesticide wastes are toxic. Follow applicable EPA and OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U072
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per Clean Water Act, Sec. 311(b)(4), Sec. 307(a), and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. A gas mask with organic vapor canister and dust filter is suitable to 1000 ppm. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Neoprene gloves are recommended.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below OSHA PELs and ACGIH TLVs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from all heat and ignition sources and oxidizing agents. *p*-Dichlorobenzene melts at 127 °F (53 °C). Protect containers against physical damage.
Engineering Controls: Avoid dust or vapor inhalation and eye and skin contact (especially when heated). Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide preplacement and annual physical examinations that emphasize the liver (liver function tests), upper respiratory tract, and eyes.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Dichlorobenzene, para, solid
DOT Hazard Class: ORM-A
ID No.: UN1592
DOT Label: None
DOT Packaging Exceptions: 173.505
DOT Packaging Requirements: 173.510

IMO Shipping Name: *p*-Dichlorobenzene
IMO Hazard Class: 6.1
ID No.: UN1592
IMO Label: St. Andrews Cross
IMDG Packaging Group: III

MSDS Collection **References:** 1-7, 9, 10, 12, 14, 16, 23, 26, 31, 34, 38, 43, 48, 73, 84, 85, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 139, 140, 142, 143, 146, 148
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 517
Pentachlorophenol

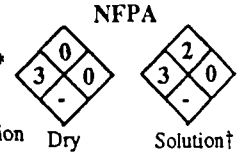
Issued: 10/83 Revision: A, 11/90

Section 1. Material Identification

Pentachlorophenol (C_6HCl_5O) Description: Derived by chlorination of phenol in the presence of a catalyst. Used as a fungicide, a bactericide, a molluscicide, an algicide, an insecticide (termite control) and herbicide (pre-harvest defoliant); in sodium pentachlorophenate; in wood preservation (telephone poles, pilings, etc.), wood products, starches, dextrins, and glues. Other registered industrial uses include boat and building construction; treatment of cable coverings, canvas belting, nets, and construction lumber and poles; mold control in petroleum drilling and production; incorporation in paints, pulp, pulp stock, paper, cooling tower water, and hardboard and particle board. Registered homeowner uses include maintenance of boats, trailers, station wagons, siding, fences, and outdoor furniture.
Other Designations: CAS No. 0087-86-5, chlorophen, PCP, penchlorol, penta.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.
Cautions: Pentachlorophenol is *highly toxic by skin absorption, ingestion, and inhalation.* The agent is highly irritating. General metabolism, the heart, the circulatory system, the liver, and the kidneys may be affected.

R 1
I 3
S 2*
K 0
* Skin absorption

NFPA



Dry Solution†

HMIS	HMIS
H 3	H 3
F 0	F 2
R 0	R 0
PPG‡	PPG‡
‡ Sec. 8	‡ Sec. 8

† PCP is freely soluble in alcohol, ether, and benzene. Depending on medium, PCP's health and flammability hazards increase in solution with such media.

Section 2. Ingredients and Occupational Exposure Limits

Pentachlorophenol, ca 100%*

1989 OSHA PEL
8-hr TWA (skin): 0.5 mg/m³

1990-91 ACGIH TLV
TWA (skin): 0.5 mg/m³

1985-86 Toxicity Data†
Rat, oral, LD_{50}: 27 mg/kg ingested affects the vascular (blood pressure elevation), endocrine (hyperglycemia), nutritional, and gross metabolic (body temperature increase) systems
Rat, inhalation, LC_{50}: 355 mg/m³ inhaled affects behavior (excitement; muscle contraction or spasticity) and respiration (shortness of breath)

1987 IDLH Level
150 mg/m³

1988 NIOSH REL
None established

* Technical grade pentachlorophenol contains traces of hexa, hepta, and octachlorodibenzo-p-dioxins; hexa, hepta, and octachlorodibenzofurans; and hexachlorobenzene.
† See NIOSH, *RTECS* (SM6300000), for additional irritative, mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 588 to 590 °F (309 to 310 °C),* 592 °F (311 °C) (decomposes)†
Melting Point: 374 °F (190 °C),* 374 °F (190 °C)†
Vapor Pressure: 0.00011 mm Hg at 77 °F (25 °C)
Vapor Density (Air = 1): 9.2
Molecular Weight: 266.35
Specific Gravity (22 °C/4 °C): 1.978
Water Solubility: 14 mg/l at 20 °C

Appearance and Odor: Light brown or tan flake or solid with a phenolic odor and pungent taste. Odor detection is at 1.6 mg/l.

* Pentachlorophenol solution
† Dry pentachlorophenol

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Since pentachlorophenol is noncombustible, use extinguishing media appropriate to the surrounding fire: dry chemical, water spray, carbon dioxide, or foam. Use the water spray to cool fire-exposed containers.
Unusual Fire or Explosion Hazards: When involved in a fire, pentachlorophenol emits toxic fumes. Wood treated with 5% pentachlorophenol solution or pentachlorophenol in petroleum solvents such as mineral spirits or kerosine are combustible.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Avoid skin contact. If feasible, remove containers from fire area. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Pentachlorophenol is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Pentachlorophenol solutions subjected to sunlight or ultraviolet light undergo photochemical degradation.
Chemical Incompatibilities: Pentachlorophenol is incompatible with strong oxidizers and alkalies.
Conditions to Avoid: Avoid contact with heat and ignition sources (open flame, electric arcs, or hot surfaces) which can cause thermal decomposition.
Hazardous Products of Decomposition: Thermal oxidative decomposition of pentachlorophenol can produce hydrogen chloride, chlorine, and chlorinated hydrocarbons. Prolonged heating above 392 °F (200 °C) produces traces of octachlorodibenzo-para-dioxin.

Section 6. Health Hazard Data

Carcinogenicity: There is animal evidence of an increase in liver and endocrine tumors in some research studies, but not in others. Also, PCP shares some structural similarity to other carcinogens. However, NTP, IARC, and OSHA do not list PCP as a carcinogen. It may be toxic to the fetus, especially during early pregnancy.
Summary of Risks: Airborne exposure is irritating to the eyes, skin, throat, and lungs, and may cause acute and possibly chronic effects (see below). Levels above 1 mg/m³ may cause cough, sneezing, and tearing of the eyes, especially in unacclimated workers. Skin contact is also irritating and provides an efficient way for the chemical to enter the body and cause systemic poisoning. Skin rashes (dermatitis) including chloracne (a severe and persistent cystic form of acne characterized by blackheads, whiteheads, and yellow cysts) may result from repeated or prolonged contact with even dilute solutions (e.g., 1%). Ingestion may cause severe systemic poisoning.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Medical Conditions Aggravated by Long-Term Exposure: Individuals with kidney, liver, endocrine, and metabolic disorders may be at a higher risk from exposure to pentachlorophenol. Consult a physician.
Target Organs: Cardiovascular system, endocrine system, general metabolism, liver, kidneys, respiratory system, eyes, skin, and central nervous system (CNS).
Primary Entry Routes: Inhalation, skin absorption, ingestion, eye contact.
Acute Effects: Acute exposures are irritating and may cause tachycardia (rapid heartbeat), tachypnea (rapid breathing), hypertension (high blood pressure), fevers, muscular weakness, anorexia (loss of appetite), sweating, dizziness, and nausea. Very high doses may cause unconsciousness, seizures (convulsions), or death due to cardiac arrest. The risk of acute poisoning may increase in hot weather.
Chronic Effects: Absorption of PCP and/or its contaminants may cause chloracne. Bronchitis and weight loss may develop. Animal studies suggest that liver and kidney damage may occur.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing with artificial respiration, CPR if necessary, and oxygen if available.
Ingestion: Call a physician or Poison Control Center immediately. Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water, then induce vomiting. If possible, induce vomiting under medical supervision. Do not instill milk or other materials containing vegetable or animal fats since they are likely to enhance absorption.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Severe systemic poisoning results primarily from uncoupling of mitochondrial oxidative phosphorylation, with ensuing hyperpyrexia. Promote heat loss and aggressively manage hyperthermia with physical methods. *Antipyretics (including aspirin), atropine, and phenothiazines are contraindicated.* Force diuresis to reduce body burden. Carefully follow and treat fluid/electrolyte and acid/base alterations. Treat supportively and reduce anxiety. Diagnostic testing should include rectal temperature, PCP urine or plasma levels, blood chemistries (including electrolytes, LFTs, BUN, creatinine), and CBC. Treat ingestion with emesis, gastric lavage, and saline cathartic.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, provide adequate ventilation, and remove all heat and ignition sources. Cleanup personnel need full protection against vapor inhalation and contact with solution or solid. Collect dry spilled material in a metal container for reclamation or disposal. For liquid spills, collect with an absorbent solid and place in a metal container for disposal. For large liquid spills, dike far ahead of liquid spill to contain. Wash residue with soap and water. Prevent spills from entering sewers, streams, and open waters. Pentachlorophenol is toxic to fish and wildlife. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), RCRA Waste No. U242
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 10 lb (4.54 kg) [* per Clean Water Act, Sec. 311(b)(4), Sec. 307(a), and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, where concentrations of pentachlorophenol exceed or are likely to exceed .5 mg/m^3, wear a NIOSH-approved organic vapor-dust filter type respirator; a full facepiece is needed at concentrations >2.5 mg/m^3. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA; SCBA can be used to 150 mg/m^3. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves (polyvinyl chloride, neoprene or nitrile latex), boots, aprons, and gauntlets to prevent skin contact. Extremely high concentrations may require a full containment suit. Always consult an industrial hygienist.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below both OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing. Use separate lockers for street clothes.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in properly labeled and closed containers in a cool, dry, well-ventilated, low fire hazard area away from heat and ignition sources and combustible materials. Protect containers from physical damage. Outside or detached storage is preferred. Accumulated sludge at the bottom of dipping tanks may concentrate toxic impurities at much higher levels than original product. Do not reuse drums. Clean empty drums, liners, and block wrappings in accordance with 40 CFR 261.7(b)(3) prior to returning for reconditioning, recycling, or other disposal.
Engineering Controls: Educate workers about pentachlorophenol's hazards. Avoid skin contact and vapor or dust inhalation. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Medical Surveillance: Preplacement and periodic medical evaluations should include a complete history and physical examination and a biochemical profile (including LFTs, BUN, creatinine, and electrolytes). Consider baseline pulmonary function tests. Perform biologic monitoring for PCP levels at the end of work shifts (plasma) and toward end of workweek (urine). 24-hr urine collections are more accurate than spot testing.

Transportation Data (49 CFR 172.102)

IMO Shipping Name: Chlorophenols, liquid
IMO Hazard Class: 6.1
ID No.: UN2021
IMO Label: St. Andrews Cross
IMDG Packaging Group: III

IMO Shipping Name: Chlorophenols, solid
IMO Hazard Class: 6.1
ID No.: UN2020
IMO Label: St. Andrews Cross
IMDG Packaging Group: III

MSDS Collection **References:** 1, 38, 73, 84, 85, 88, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 140, 143, 146
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 536
Benzyl Alcohol

Issued: 5/85 Revision: A, 5/93

Section 1. Material Identification

Benzyl Alcohol ($C_6H_5CH_2OH$) Description: Occurs naturally in jasmine, hyacinth, and dozens of other essential oils. Derived commercially by hydrolysis of benzyl chloride, catalytic reduction of benzaldehyde, the Grignard reaction of bromobenzene and formaldehyde or benzyl chloride and oxygen, or by action of sodium or potassium carbonate on benzyl chloride. Used in the preparation of perfumes, pharmaceuticals (antimicrobial aid in the preservation of parenteral drugs), cosmetics, inks, and benzyl esters; in microscopy as an embedding material; degreasing agent in rug cleaners; solvent for dyestuffs, cellulose esters, casein, and waxes; and for heat-sealing polyethylene films.

R 1
I 2
S 2*
K 2
*Skin absorption

NFPA

HMIS
H 2
F 1
R 0
PPE*
* Sec. 8

Other Designations: CAS No. 100-51-6, *alpha*-hydroxytoluene, benzal alcohol, benzene carbinol, benzene methanol, Benzylicum, Euxyl K100, NCI-C06111, phenyl carbinol, phenyl methanol, phenyl methyl alcohol, *alpha*-toluenol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Benzyl alcohol is irritating to the eyes, skin, and mucous membranes. Severe exposures can cause central nervous system effects. It is combustible when exposed to heat or flame.

Section 2. Ingredients and Occupational Exposure Limits

Benzyl alcohol, ca 100%

1992 OSHA PEL
None established

1993-94 ACGIH TLV
None established

1992 NIOSH REL
None established

1991 DFG (Germany) MAK
None established

1992 Toxicity Data*
Rabbit, skin: 10 mg/24 hr (open patch test) caused mild irritation.
Rabbit, eye: 750 µg caused severe irritation.
Rat, oral, LD_{50}: 1230 mg/kg caused somnolence, excitement, and coma.
Rat, inhalation, LC_{Lo}: 1000 ppm/8 hr; toxic effects not yet reviewed.

* See NIOSH, *RTECS* (DN3150000), for additional irritation and toxicity data.

Section 3. Physical Data

Boiling Point: 403 °F (206 °C)
Freezing Point: 4.46 °F (-15.3 °C)
Vapor Pressure: 1 mm Hg at 136.4 °F (58 °C); 0.15 mm Hg at 77 °F (25 °C)
pH: Aqueous solutions are neutral
Viscosity: 5.8 cP at 68 °F (20 °C)
Refraction Index: 1.5385 to 1.5405 at 68 °F (20 °C)/D
Odor Threshold: 5.5 ppm

Molecular Weight: 108.15
Specific Gravity: 1.04535 at 68 °F (20/4 °C)
Water Solubility: 3.5%
Other Solubilities: Soluble in acetone, benzene, chloroform, ethyl alcohol, ethyl ether, aromatic hydrocarbons, and vegetable oils.
Octanol/Water Partition Coefficient: Log Kow = 1.10
Critical Temperature: 757 °F (403 °C)

Appearance and Odor: Colorless to water-white liquid with a faint, aromatic odor and a sharp, burning taste.

Section 4. Fire and Explosion Data

Flash Point: 200 °F (93 °C) CC	Autoignition Temperature: 817 °F (436 °C)	LEL: None reported	UEL: None reported

Extinguishing Media: Fight fires with dry chemical, carbon dioxide, or alcohol-resistant foam. Water may be used but could cause frothing.
Unusual Fire or Explosion Hazards: Burning rate = 3.74 mm/minute.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Do not release runoff from fire control methods to sewers or waterways; dike for proper disposal.

Section 5. Reactivity Data

Stability/Polymerization: Benzyl alcohol slowly oxidizes in air to benzaldehyde and benzoic acid. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Include sulfuric and other acids, hydrogen bromide + iron at > 100 °C (exothermic polymerization), and oxidizing agents. It will attack some plastics.
Conditions to Avoid: Exposure to heat, ignition sources, and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of benzyl alcohol can produce acrid smoke and fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[183] NTP,[169] and OSHA[183] do not list benzyl alcohol as a carcinogen.
Summary of Risks: Benzyl alcohol is irritating to the eyes, skin, and respiratory tract. It can be absorbed through the skin with a local anesthetic effect. Severe exposures can result in neurologic, liver (benzyl alcohol is metabolized in the liver), kidney, and blood disturbances. No chronic industrial illnesses are known and most human toxicity data is based on responses of infants given medicine containing benzyl alcohol as a preservative. Contact dermatitis is possible after repeated exposure.
Medical Conditions Aggravated by Long-Term Exposure: Skin, neurologic, liver, kidney, or blood disorders.
Target Organs: Eyes, skin, central nervous system, blood, kidneys, and liver.
Primary Entry Routes: Inhalation, skin and eye contact, ingestion.
Acute Effects: The application of 100% and 1 to 4% solutions have caused anesthesia lasting for 2 hours and 30 minutes, respectively. Prolonged or excessive inhalation can cause headache, nausea, vomiting, diarrhea, and in severe cases may cause respiratory ...

Continue on next page

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Section 6. Health Hazard Data, *continued*

stimulation followed by respiratory or muscle paralysis, convulsions, unconsciousness, and death. Ingestion may cause gastrointestinal tract irritation, followed by nausea, cramps, diarrhea, and possible tissue ulceration. Solutions greater than 30% can cause spontaneous vomiting. Infants given medicine (rectally) with benzyl alcohol as a preservative have suffered severe symptoms resulting in death. Effects included gradual neurologic deterioration, severe metabolic acidosis, gasping respiration, skin breakdown, liver and kidney failure, hypotension, blood abnormalities, and cardiovascular collapse. It is not known whether severe industrial exposures will result in similar effects.

Chronic Effects: Possible dermatitis; although rare, contact dermatitis (both delayed and immediate hypersensitivity reactions) is documented.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Monitor for metabolic acidosis, CNS depression, and hypotension. Presence of benzyl alcohol and benzoic acid in the blood and hippuric acid in the urine may aid in diagnosis. Treatment is symptomatic and supportive.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against inhalation and skin/eye contact. Take up small spills with earth, sand, vermiculite, or other, absorbent, noncombustible material and place in suitable containers. Dike far ahead of large spill for reclamation or disposal. Prevent entry into sewers, drains, and waterways. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Degradation:** Benzyl alcohol is highly mobile in soil and readily leaches. Some may volatilize from dry soils, but not moist. Microbial degradation is possible. In water, microbial degradation is possible under both aerobic and anaerobic conditions. It should not significantly bioconcentrate. In air, benzyl alcohol should exist almost entirely in the vapor-phase. The est. half-life with photochemically produced hydroxyl radicals is 2 days. **Ecotoxicity Values:** *Daphnia magna*, TLm = 360 ppm/48 hr; *Pimephales promelas* (fathead minnow), LC_{50} = 480 and 770 mg/L in 72 and 48 hrs., respectively; *Lepomis macrochirus* (bluegill sunfish), LC_{50} = 10 ppm/96 hr.

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

EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Other: Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber to prevent skin contact.

Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations as low as possible. Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Separate contaminated work clothes from street clothes and launder before reuse. Remove benzyl alcohol from your shoes and clean PPE.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using benzyl alcohol, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage/Handling Requirements: Prevent physical damage to containers. Store in airtight containers in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level.

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the skin, liver, kidney, central nervous system, and blood.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Combustible liquid, n.o.s. *
DOT Hazard Class: Combustible liquid
ID No.: NA1993
DOT Packing Group: III
DOT Label: None
Special Provisions (172.102): T1

Packaging Authorizations
a) **Exceptions:** 173.150
b) **Non-bulk Packaging:** 173.203
c) **Bulk Packaging:** 173.241

Quantity Limitations
a) **Passenger Aircraft or Railcar:** 60 L
b) **Cargo Aircraft Only:** 220 L

Vessel Stowage Requirements
a) **Vessel Stowage:** A
b) **Other:** —

* The DOT defines a combustible liquid as one having a flash pt. between 141 °F (60.5 °C) and 200 °F (93 °C). References consulted by Genium varied with flash pts. between 200 °F and 213 °F. Therefore, each company must determine before shipping, the exact flash pt. of their brand of benzyl alcohol.

MSDS Collection **References:** 73, 101, 103, 124, 126, 127, 132, 136, 139, 149, 159, 168, 183, 186
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** TW Thoburn, MPH, MD

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Sheet No. 711
Pyrene

Issued: 4/90

Section 1. Material Identification

Pyrene Description: A condensed ring, polyaromatic hydrocarbon compound derived from coal tar. Also synthesized from o,o'-ditolyl. Used in biochemical research and as starting material for synthesizing benzo(a)pyrene. An ingredient of smoked and broiled meat, tobacco smoke, and air pollution.
Other Designations: CAS No. 0129-00-0; $C_{16}H_{10}$; beta-pyrene; benzo(d,e,f)phenanthrene; benzo(d,e,f)phenathrene.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.

R 1
I 3
S 2*
K -
* Skin absorption

Genium

HMIS
H 2
F 1
R 0
PPG†
† Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Pyrene, ca 100%

OSHA PEL	ACGIH TLV, 1989-90	NIOSH REL, 1987	Toxicity Data*
8-hr TWA: 0.2 mg/m³	None established	None established	Rat, oral, LD_{50}: 2700 mg/kg ingested produces conjunctiva irritation, excitement, and muscle contraction Rat, inhalation, LC_{50}: 170 mg/m³ inhaled produces conjunctiva irritation, excitement, and muscle contraction Gene mutation in mammalian cells; human cell types: 12 µmol/l

* See NIOSH, *RTECS* (UR2450000), for additional mutative, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 759 °F/404 °C
Melting Point: 313 °F/156 °C
Vapor Pressure: 6.85 x 10^{-7} torr at 68 °F/20 °C
Molecular Weight: 202.26 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.271 at 73 °F/23 °C
Water Solubility: Insoluble (0.135 mg/l)

Appearance and Odor: Colorless solid or a slight blue florescent solution. Tetracene impurities give pyrene a yellow color.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: Use foam, dry chemical, and CO_2 to extinguish fire.
Unusual Fire or Explosion Hazards: Pyrene is a flammable and combustible material that heat and ignition sources may ignite. It burns rapidly with a flare-like effect.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Avoid skin contact. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Pyrene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Hazardous Products of Decomposition: Thermal oxidative decomposition of pyrene can emit irritating fumes and acrid smoke.

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists pyrene as a carcinogen.
Summary of Risks: Pyrene is irritating to exposed skin and eyes, moderately toxic by ingestion and intraperitoneal routes, and a poison by inhalation. Experimental studies show pyrene is a tumorigen in animals and a mutagen in humans. Workers exposed to concentrations between 3 and 5 mg/m³ showed some unspecified teratogenic effects. In general, human exposure occurs mainly through inhalation of tobacco smoke and polluted air. Although ingesting smoked and broiled meats may expose humans to pyrene, there is little indication of serious health effects.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, respiratory tract.
Primary Entry Routes: Inhalation, ingestion, skin contact.
Acute Effects: Vapor inhalation may irritate the nose mucosa and respiratory tract. Vapors may also cause conjunctival irritation. Pyrene is absorbed through intact skin and causes dermal irritation. Ingestion may irritate and burn the esophagus and gastrointestinal tract.
Chronic Effects: None reported.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of milk or water. Do not induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Observe patients with dermal exposure for systemic poisoning since pyrene is absorbed through intact skin.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, and remove all heat and ignition sources. Cleanup personnel should protect against vapor inhalation and skin and eye contact. Scoop spilled material into appropriate disposal containers. Absorb liquid with inert, noncombustible material and place waste in appropriate disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per Clean Water Act, Sec. 307(a)]
Listed as SARA Extremely Hazardous Substance (40 CFR 355), Reportable Quantity: 5000 lb, Threshold Planning Quantity (TPQ): 1000/10,000 lb
SARA Toxic Chemical (40 CFR 372.65): Not listed
OSHA Designations
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[109]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, well-ventilated area. Protect containers from physical damage.
Engineering Controls: Avoid vapor inhalation and skin contact. Practice good personal hygiene and housekeeping procedures. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. Provide preplacement and periodic medical examinations, including comprehensive medical histories with emphasis on the oral cavity, respiratory tract, bladder, and kidneys. Examine the skin for premalignant and malignant lesions.
Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection **References:** 7, 73, 87, 103, 123, 124, 126, 127, 136
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

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Material Safety Data Sheets Collection:

Sheet No. 713
Lead (Inorganic)

Issued: 8/90

Section 1. Material Identification

Lead (Inorganic) (Pb) Description: Exists widely throughout the world in a number of ores. Its main commercial source is galena (lead sulphide). Lead mineral is separated from crude ores by blast-furnace smelting, drossing, or electrolytic refining. Lead is used mostly in manufacturing storage batteries. Other uses are in manufacturing tetraethyllead and both organic and inorganic lead compounds in ceramics, plastics, and electronic devices; in producing ammunition, solder, cable covering, sheet lead, and other metal products (brass, pipes, caulking); in metallurgy; in weights and as ballast; as a chemical intermediate for lead alkyls and pigments; as a constuction material for the tank linings, piping, and equipment used to handle the corrosive gases and liquids used in sulfuric acid manufacturing, petroleum refining, halogenation, sulfonation, extraction, and condensation; and for x-ray and atomic radiation protection.

R	0	Genium
I	4	
S	-	1 / 3 0 / -
K	0	

HMIS
H 3
F 1
R 0
PPG*

Other Designations: CAS No. 7439-92-1, lead oxide; lead salts, inorganic; metallic lead; plumbum.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.

Cautions: *Inorganic lead is a potent systemic poison.* Organic lead (for example, tetraethyl lead) has severe, but different, health effects. * Sec. 8
Occupational lead poisoning is due to inhalation of dust and fumes. Major affected organ systems are the nervous, blood, and reproductive systems, and kidneys. Health impairment or disease may result from a severe acute short- or long-term exposure.

Section 2. Ingredients and Occupational Exposure Limits

Lead (inorganic) fumes and dusts, as Pb, ca 100%

1989 OSHA PELs (Lead, inorganic compounds)
8-hr TWA: 50 µg/m³
Action Level TWA*: 30 µg/m³

29 CFR 1910.1025 Lead Standard
Blood Lead Level: 40 µg/100 g

1989-90 ACGIH TLV (Lead, inorganic, fumes and dusts)
TLV-TWA: 150 µg/m³

1988 NIOSH REL
10-hr TWA: <100 µg/m³

1985-86 Toxicity Data†
Human, inhalation, TC_{Lo}: 10 µg/m³ affects gastrointestinal tract and liver
Human, oral, TD_{Lo}: 450 mg/kg ingested over 6 yr affects peripheral and central nervous systems
Rat, oral, TD_{Lo}: 790 mg/kg affects multigeneration reproduction

* Action level applies to employee exposure without regard to respirator use.
† See NIOSH, *RTECS* (OF7525000), for additional mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 3164 °F (1740 °C)
Melting Point: 621.3 °F (327.4 °C)
Vapor Pressure: 1.77 mm Hg at 1832 °F (1000 °C)
Viscosity: 3.2 cp at 621.3 °F (327.4 °C)
Molecular Weight: 207.20
Specific Gravity (20 °C/4 °C): 11.34
Water Solubility: Relatively insoluble in hot or cold water*

Appearance and Odor: Bluish-white, silvery, gray, very soft metal.

* Lead dissolves more easily at a low pH.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: Use dry chemical, carbon dioxide, water spray, or foam to extinguish fire.
Unusual Fire or Explosion Hazards: Flammable and moderately explosive in the form of dust when exposed to heat or flame.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Lead is stable at room temperature in closed containers under normal storage and handling conditions. It tarnishes on exposure to air. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Mixtures of hydrogen peroxide + trioxane explode on contact with lead. Lead is incompatible with sodium azide, zirconium, disodium acetylide, and oxidants. A violent reaction on ignition may occur with concentrated hydrogen peroxide, chlorine trifluoride, sodium acetylide (with powdered lead), ammonium nitrate (below 200 °C with powdered lead). Lead is attacked by pure water and weak organic acids in the presence of oxygen. Lead is resistant to tap water, hydrofluoric acid, brine, and solvents.
Conditions to Avoid: Rubber gloves containing lead may ignite in nitric acid.
Hazardous Products of Decomposition: Thermal oxidative decomposition of lead can produce highly toxic fumes of lead.

Section 6. Health Hazard Data

Carcinogenicity: Although the NTP and OSHA do not list lead as a carcinogen, the IARC lists it as probably carcinogenic to humans, but having (usually) no human evidence. However, the literature reports instances of lead-induced neoplasms, both benign and malignant, of the kidney and other organs in laboratory rodents. Excessive exposure to lead has resulted in neurologic disorders in infants. Experimental studies show lead has reproductive and teratogenic effects in laboratory animals. Human male and female reproductive effects are also documented.
Summary of Risks: Lead is a potent, systemic poison that affect a variety of organ systems, including the nervous system, kidneys, reproductive system, blood formation, and gastrointestinal (GI) system . The most important way lead enters the body is through inhalation, but it can also be ingested when lead dust or unwashed hands contaminate food, drink, or cigarettes. Much of ingested lead passes through feces without absorption into the body. Adults may absorb only 5 to 15% of ingested lead; children may absorb a much larger fraction. Once in the body, lead enters the bloodstream and circulates to various organs. Lead concentrates and remains in bone for many years. The amount of lead the body stores increases as exposure continues, with possibly cumulative effects. Depending on the dose entering the body, lead can be deadly within several days or affect health after many years. Very high doses can cause brain damage (encephalopathy).
Medical Conditions Aggravated by Exposure: Lead may aggravate nervous system disorders (e.g., epilepsy, neuropathies), kidney diseases, high blood pressure (hypertension), infertility, and anemia. Lead-induced anemia and its effect on blood presssure can aggravate cardiovascular disease.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Target Organs: Blood, central and peripheral nervous systems, kidneys, and gastrointestinal (GI) tract.
Primary Entry Routes: Inhalation, ingestion.
Acute Effects: An acute, short-term dose of lead could cause acute encephalopathy with seizures, coma, and death. However, short-term exposures of this magnitude are rare. Reversible kidney damage can occur from acute exposure, as well as anemia.
Chronic Effects: Symptoms of chronic long-term overexposure include appetite loss, nausea, metallic taste in the mouth, lead line on gingival (gum) tissue, constipation, anxiety, anemia, pallor of the face and the eye grounds, excessive tiredness, weakness, insomnia, headache, nervous irritability, fine tremors, numbness, muscle and joint pain, and colic accompanied by severe abdominal pain. Paralysis of wrist and, less often, ankle extensor muscles may occur after years of increased lead absorption. Kidney disease may also result from chronic overexposure, but few, if any, symptoms appear until severe kidney damage has occurred. Reproductive damage is characterized by decreased sex drive, impotence, and sterility in men; and decreased fertility, abnormal menstrual cycles, and miscarriages in women. Unborn children may suffer neurologic damage or developmental problems due to excessive lead exposure in pregnant women. Lead poisoning's severest result is encephalopathy manifested by severe headache, convulsions, coma, delirium, and possibly death.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Consult a physician if any health complaints develop.
Inhalation: Remove exposed person to fresh air and support breathing as needed. Consult a physician.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If large amounts of lead were ingested, induce vomiting with Ipecac syrup. Consult a physician immediately.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: For diagnosis, obtain blood pressure, blood lead level (PbB), zinc protoporphyrin (ZPP), complete blood count for microcytic anemia and basophilic stippling, urinalysis, and blood urea nitrogen (BUN) of creatinine. Examine peripheral motor neuropathy, pallor, and gingival lead line. Use Ca-EDTA to treat poison, but *never* chelate prophylactically. Consult an occupational physician or toxicologist.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel and evacuate all unnecessary personnel immediately. Cleanup personnel should protect against inhalation of dusts or fume and contact with skin or eyes. Avoid creating dusty conditions. Water sprays may be used in large quantities to prevent the formation of dust. Cleanup methods such as vacuuming (with an appropriate filter) or wet mopping minimizes dust dispersion. Scoop the spilled material into closed containers for disposal or reclamation. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33, Appendix II—EP Toxicity Test Procedures)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per Clean Water Act, Sec. 307(a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. Protective clothing made of man-made fibers and lacking turn-ups, pleats, or pockets retain less dust from lead.
Ventilation: Provide general and local ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially washing hands before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from all incompatible materials, direct sunlight, and heat and ignition sources.
Engineering Controls: Educate worker about lead's hazards. Follow and inform employees of the lead standard (29 CFR 1910.1025). Avoid inhalation of lead dust and fumes and ingestion of lead. Use only with appropriate personal protective gear and adequate ventilation. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Avoid creating dusty conditions. Segregate and launder contaminated clothing. Take precautions to protect laundry personnel. Practice good personal hygiene and housekeeping procedures. For a variety of reasons, the lead concentration in workroom air may not correlate with the blood lead levels in individuals.
Other Precautions: Provide preplacement and periodic medical examinations which emphasize blood, nervous system, gastrointestinal tract, and kidneys, including a complete blood count and urinalysis. Receive a complete history including previous surgeries and hospitalization, allergies, smoking history, alcohol consumption, proprietary drug intake, and occupational and nonoccupational lead exposure. Maintain records for medical surveillance, airborne exposure monitoring, employee complaints, and physician's written opinions for at least 40 years or duration of employment plus 20 years. Measurement of blood lead level (PbB) and zinc protoporphyrin (ZPP) are useful indicators of your body's lead absorption level. Maintain worker PbBs at or below 40 µg/100 g of whole blood. To minimize adverse reproductive health effects to parents and developing fetus, maintain the PbBs of workers intending to have children below 30 µg/100 g. Elevated PbBs increase your risk of disease, and the longer you have elevated PbBs, the greater your chance of substantial permanent damage.

Transportation Data (49 CFR 172.102)
IMO Shipping Name: Lead compounds, soluble, n.o.s.
IMO Hazard Class: 6.1
ID No.: UN2291
IMO Label: St. Andrews Cross (X, Stow away from foodstuffs)
IMDG Packaging Group: III

MSDS Collection **References:** 26, 38, 73, 84, 85, 88, 89, 90, 100, 101, 103, 109, 124, 126, 132, 133, 134, 136, 138, 139, 142, 143
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 723
Nickel Metal

Issued: 8/90

Section 1. Material Identification

Nickel (Ni) Description: Found in ores in combination with sulphur, oxygen, antimony, arsenic, and/or silica. The Orford (sodium sulfide and electrolysis) and the Mond (nickel carbonyl) processes are used to refine nickel. Used in electroplating, casting operations for machine parts, manufacturing acid-resisting and magnetic alloys and tapes, synthesizing acrylic esters; in surgical and dental prostheses, coinage, catalytic gastrification of coal, paint pigments, Ni-Cd batteries, ceramics and glass; and as a catalyst in hydrogenation of fats and oils.
Other Designations: CAS No. 7440-02-0, Raney alloy, Raney nickel.*
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.

Cautions: Nickel is an eye, skin, and respiratory tract irritant. *Chronic inhalation of nickel dust or fumes may cause cancer of the lungs and nasal passages. Nickel powder (Raney nickel) is a dangerous fire hazard.*

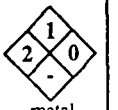
	R	I	S	K
	0	3	2	1

NFPA

catalyst

HMIS	
H	2
F	4
R	0
PPG†	

Genium



metal

HMIS	
H	2
F	1
R	0
PPG†	

† Sec. 8

* Raney nickel is prepared by leaching (with 25% caustic soda solution) aluminum from an alloy of 50% aluminum and 50% nickel. It is used as a catalyst for hydrogenation Raney nickel, a silvery gray metal powder, is a dangerous fire risk and ignites spontaneously in air (Sec. 4). Nickel catalysts cause many industrial accidents.

Section 2. Ingredients and Occupational Exposure Limits

Nickel, ca 100%

1989 OSHA PEL
8-hr TWA: 1 mg/m³

1989-90 ACGIH TLV
TLV-TWA: 1 mg/m³

1988 NIOSH REL
0.015 mg/m³

1985-86 Toxicity Data*
Dog, intravenous, LD_{Lo}: 10 mg/kg
Guinea pig, oral, LD_{Lo}: 5 mg/kg
Rat, implant, TD_{Lo}: 250 mg/kg

* See NIOSH, *RTECS* (QR5950000), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 4946 °F (2730 °C)
Melting Point: 2651 °F (1455 °C)
Vapor Pressure: 1 mm at 3290 °F (1810 °C)
Atomic Weight: 58.71
Density: 8.90 at 25 °C
Water Solubility: Insoluble

Appearance and Odor: A silvery-white, hard, malleable and ductile metal.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Smother with suitable dry powder or use large amounts of water.
Unusual Fire or Explosion Hazards: Nickel is combustible as dust or powder. Raney nickel ignites spontaneously in air. Nickel carbonyl (*MSDS Collection*, No. 226), a highly toxic substance, may form under fire conditions.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since nickel dust or powder is toxic if inhaled, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Nickel is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Nickel can react violently with fluorine, ammonium nitrate, hydrogen + dioxane, performic acid, selenium, sulfur, ammonia, hydrazine, phosphorus, and titanium + potassium chlorate. Nickel is also incompatible with oxidants. Raney nickel catalysts may initiate hazardous reactions with sulfur compounds, *p*-dioxane, hydrogen, hydrogen + oxygen, ethylene + aluminum chloride, magnesium silicate, methanol, and organic solvents + heat.
Conditions to Avoid: Avoid incompatibilities.
Hazardous Products of Decomposition: Thermal oxidative decomposition of nickel can produce highly toxic nickel carbonyl.

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Section 6. Health Hazard Data

Carcinogenicity: The IARC and NTP classify nickel as, respectively, a human carcinogen (Group 1) and an anticipated human carcinogen.
Summary of Risks: Nickel dust or fume is a respiratory irritant that with chronic exposure may cause nasal or lung cancer in humans. The average latency period for the induction of these cancers appears to be about 25 yr (within a 4- to 51-yr range). Experimental studies show nickel also has neoplastigenic, tumorigenic, and teratogenic effects in laboratory animals. Hypersensitivity to nickel is common and can cause conjunctivitis, allergic contact dermatitis, and asthma. The allergic contact dermatitis ("nickel-itch," a pink papular erythema with pustulation and ulceration) usually clears within one week, but sensitization is permanent.
Medical Conditions Aggravated by Long-Term Exposure: Chronic pulmonary, upper respiratory tract, and skin disorders. Carcinoma of the paranasal sinuses, larynx, and lung may also develop.
Target Organs: Nasal cavities, lungs, skin.
Primary Entry Routes: Inhalation, dermal contact, and ingestion.
Acute Effects: Exposure to nickel fumes can cause upper respiratory tract irritation (with nonproductive cough, rapid breathing, dyspnea, chest tightness), metal fume fever (chills, fever, flu-like symptoms), asthma, inflammation of the lungs (noninfectious pneumonia), eye (conjunctiva) irritation, nausea, vomiting, and abdominal pain. Dermal contact causes "nickel itch." Ingesting large doses causes nausea, vomiting, and diarrhea.
Chronic Effects: Prolonged or repeated contact can cause nickel sensitization. Symptoms of sensitization include nickel dermatitis with eczematous skin and lichenification (hardened and leathery skin). Chronic inhalation exposure can cause chronic pulmonary irritation, chronic thickening of the mucous membranes of the nose, nasal sinusitis, anosmia (loss or impairment of the sense of smell), and perforation of the nasal septum. Chronic exposure to dust and fumes may cause carcinoma of paranasal sinuses, larynx, and lung.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Since oral toxicity for elemental nickel is low, inducing vomiting is seldom necessary. In cases of severe vomiting or diarrhea, treat for fluid replacement.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Chronic exposure to nickel dust may cause *eosinophilic pneumonitis* (Loeffler's syndrome) which responds well to systemic cortico-steroids. There are cases of host rejection of nickel-containing prostheses after development of nickel sensitivity.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personal should protect against vapor inhalation and dermal contact. Avoid dust generation. Using nonsparking tools, carefully scoop spilled material into appropriate containers for reclamation or disposal. After completing material pickup, wash spill site. Do not release to sewers or waterways. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per Clean Water Act, Sec. 307(a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL, ACGIH TLV, and NIOSH REL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from incompatible materials (Sec. 2). Protect against physical damage. Store Raney nickel under inert gas or water in tightly closed containers away from heat or ignition sources, acids, caustics, and oxidizing materials.
Engineering Controls: Minimize all possible exposures to potential carcinogens. Avoid vapor inhalation and dermal contact. Use only with appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide preplacement and periodic medical examinations that emphasize the skin, nasal cavities, and lungs, including a 14" x 17" chest roentgenogram and urine nickel determinations.

Transportation Data (49 CFR 172.102)
IMO Shipping Name: Nickel catalyst, wetted with not less than 40% water or other suitable liquid, by weight, finely divided, activated, or spent
IMO Hazard Class: 4.2
ID No.: UN1378
IMO Label: Spontaneously combustible
IMDG Packaging Group: II

MSDS Collection **References:** 26, 38, 73, 84, 85, 88, 89, 90, 100, 101, 103, 109, 124, 126, 132, 133, 134, 136, 138, 139, 140, 142, 143
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 724
1,2-Dibromo-3-chloropropane

Issued: 8/90

Section 1. Material Identification

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1,2-Dibromo-3-chloropropane ($CH_2BrCHBrCH_2Cl$) Description: Prepared by liquid phase addition of bromine to allyl chloride at room temperature with careful temperature control. It is no longer made in the U.S. Used as a soil fumigant, pesticide, and nematocide.

Other Designations: CAS No. 0096-12-8, BBC 12, 3-chloro-1,2-dibromopropane, DBCP, Fumazone, Nemafume, Nemagon, Nemaset, OS1897.

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

R 1
I 4
S 2*
K 2
*Skin absorption

Genium

HMIS
H 3
F 2
R 1
PPG†
† Sec. 8

Cautions: DBCP is an eye and mucous membrane irritant and a testicular, liver, and kidney toxin. *Prolonged or repeated exposures to this Class IIIA combustible liquid can cause infertility and severe liver and kidney damage.*

Section 2. Ingredients and Occupational Exposure Limits

1,2-Dibromo-3-chloropropane, ca 100%

1989 OSHA PEL
8-hr TWA: 0.001 ppm

1989-90 ACGIH TLV
None established

1989 NIOSH REL
Ceiling: 0.01 ppm/30 min

1985-86 Toxicity Data*
Rat, inhalation, LC_{50}: 103 ppm/8 hr; toxic effects not yet reviewed
Rat, oral, TD_{Lo}: 5475 mg/kg administered intermittently over 73 weeks in a number of separate, discrete doses produces gastrointestinal, skin, and appendage tumors
Rat, oral, TD_{Lo}: 500 mg/kg (6-15D preg); effects on embryo or fetus (fetotoxicity)

* See NIOSH, *RTECS* (TX8750000), for additional irritative, mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 383 °F (195 °C)
Melting Point: 43 °F (6 °C)
Vapor Pressure: 0.8 mm Hg at 20 °C
Vapor Density (Air = 1): 2.09 at 57.2 °F (14 °C)
Evaporation Rate (BuAc = 1): very much less than 1
Molecular Weight: 236
Specific Gravity: 2.09 at 57.2 °F (14 °C)
Water Solubility: 0.1% wt/wt

Appearance and Odor: An amber-to-brown liquid with a pungent odor. *Any detectable DBCP odor indicates overexposure.* Its high and low odor thresholds are 0.2895 and 0.0965 mg/m³, respectively, with an irritating concentration of 1.93 mg/m³.

Section 4. Fire and Explosion Data

Flash Point: 170 °F (76.7 °C), OC	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: Use carbon dioxide or dry chemical to extinguish fires involving DBCP. Use water spray to cool fire-exposed containers. Do not apply a solid stream of water since it scatters and spreads the flame.

Unusual Fire or Explosion Hazards: Class IIIA combustible liquid.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and chemically protective clothing recommended by the manufacturer. *Structural firefighter's protective clothing is not effective.* Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: DBCP is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: DBCP is incompatible with chemically reactive metals such as magnesium, aluminum, and tin alloys.

Conditions to Avoid: Avoid contact with rubber materials and coatings since DBCP attacks these materials.

Hazardous Products of Decomposition: Thermal oxidative decomposition of DBCP can produce toxic hydrogen bromide, hydrogen chloride, and carbon monoxide gases and vapor.

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Section 6. Health Hazard Data

Carcinogenicity: The NTP and OSHA classify DBCP as, respectively, an anticipated human carcinogen and a cancer hazard. Based on inadequate human evidence and sufficient animal evidence, the IARC classifies DBCP as a possible human carcinogen (Group 2B).
Summary of Risks: DBCP is a mild skin, eye, and mucous membrane irritant. However, chronic exposure to DBCP may lead to sterility, diminished renal function, and degeneration and cirrhosis of the liver. The risk of cancer due to occupational exposure is also a concern.
Medical Conditions Aggravated by Long-Term Exposure: Testicular dysfunction.
Target Organs: Central nervous system, skin, liver, kidney, spleen, reproductive system, digestive system.
Primary Entry Routes: Inhalation, skin absorption.
Acute Effects: Inhalation can cause respiratory irritation, pulmonary congestion or edema, eye irritation, conjunctivitis, and central nervous system (CNS) depression with apathy, sluggishness, and ataxia. Inhalation of high concentrations may rapidly cause coma. Malaise, headache, irritability, and chest and abdominal pain are reported to persist for several weeks and perhaps for several years after inhalation exposure. Dermal exposure causes inflammation. Ingestion causes acute gastrointestinal distress with pulmonary congestion and edema. Although toxicity occurs more often with chronic exposures, DBCP can cause sterility even at low exposures.
Chronic Effects: Prolonged or repeated dermal exposures can cause necrosis or dermatitis. Repeated exposures can lead to infertility and severe liver and kidney damage.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water. Trained personnel should doublebag and launder or dispose of contaminated clothing.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Before inducing vomiting, check the solvent base for possible aspiration hazard. Immediately call a Poison Control Center. Unless advised otherwise, have that *conscious* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: For ingestion, consider gastric lavage or activated charcoal cathartic. Place all potentially exposed employees in a medical surveillance program that concentrates on reproductive history and testicular function (see OSHA standard for specific details and requirements). Monitor significant dermal exposures for systemic toxicity.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and skin and eye contact. For liquid spills, absorb in paper, vermiculite, or sand. For large liquid spills, dike far ahead to contain spill. For solid form, use clean, dry, nonsparking tools to collect material for reclamation or disposal. Place in appropriate containers with covers for reclamation or disposal. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: If feasible, absorb small quantities of DBCP, or place them on paper towels and burn them in a safe place such as a fume hood. Dissolve large quantities in flammable solvents and atomize them in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U066
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
LIsted as a Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. Chemically resistant standard rubber and neoprene gloves *do not protect* against DBCP. To prevent skin contact, supplied-air suits may be necessary.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and NIOSH REL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants.
Comments: Work areas should have restricted access. Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, well-ventilated area away from all heat and ignition sources and incompatible materials (Sec. 5). Protect containers from physical damage. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas.
Engineering Controls: Workers should be educated about the hazards and potential dangers of this specifically regulated substance (see 29 CFR 1910.1044 for additional information). Minimize all possible exposures to potential carcinogens such as DBCP. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation.
Other Precautions: Provide preplacement and periodic medical examinations with emphasis on the genitourinary system including a sperm count, a complete blood count, a complete urinalysis, a thyroid profile, serum testosterone, serum FSH, serum LH, and serum multiphasic analysis (SMA-12).

Transportation Data (49 CFR 172.102)
IMO Shipping Name: 1,2-Dibromo-3-chloropropane
IMO Hazard Class: 6.1
ID No.: UN2872
IMO Label: St. Andrews Cross (X, Stow away from foodstuffs)
IMDG Packaging Group: III

MSDS Collection **References:** 26, 38, 73, 85, 88, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 139, 143
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 758
Iron

Issued: 7/91

Section 1. Material Identification

Iron (Fe) Description: Occurs naturally as the second most abundant metal (~5%) in the earth's crust. Its commercial form usually contains some carbon, phosphorus, silica, sulfur, and manganese. It has four naturally occurring isotopes: 54, 56, 57 and 58, and six artificial ones: 52, 53, 55, 59, 60, and 61. Iron is purified by smelting ore with limestone and coke in blast furnaces (purity 91 to 92 %), or by continuous direct reduction of iron ore with limestone heated to 1699 °F (926 °C), melted at 3499 °F (1926 °C), and then reduced to iron at 2998 °F (1648 °C) with powdered coal (purity 99%). The powder form is obtained by treating ore or scrap metal with hydrochloric acid to give ferrous chloride solution, then filtrating, vacuum crystallizing, dehydrating, and reducing it at 1472 °F (800 °C) to metallic iron (briquettes or powder); or by thermal decomposition of iron carbonyl. Solid iron is used to alloy with carbon, manganese, chromium, nickel, and other elements to form steel. Its radioisotopes (^{55}Fe and ^{59}Fe) are used in biological tracer studies. The powder form is used in metallurgy products, magnets, high-frequency cores, and auto parts; and as a catalyst in ammonia synthesis.
Other Designations: CAS No. 7439-89-6, Ancor En 80/150,® Armco iron,® carbonyl iron, Loha,® Suy B-2.®
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

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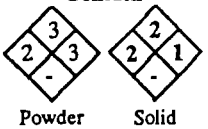

Powder Solid

R	1	HMIS	
I	2	H	2
S	1	F	2
K	1	R	1
		PPG*	

* Sec. 8

Cautions: Iron is moderately toxic by ingestion and inhalation of iron dusts and powder. The powder form is pyrophoric (ignites spontaneously upon exposure to air and other substances).

Section 2. Ingredients and Occupational Exposure Limits

Iron, ca 91 to 99%

1990 OSHA PEL	1990-91 ACGIH TLV	1990 NIOSH REL	1985-86 Toxicity Data†
8-hr TWA: 10 mg/m³*	TWA: 5 mg/m³*	5 mg/m³*	Rabbit, intraperitoneal, LD_{Lo}: 20 mg/kg; no toxic effect noted

*As iron oxide fumes.
† See NIOSH, *RTECS* (NO4565500), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 4982 °F (2750 °C)
Melting Point: 2795 °F (1535 °C)
Vapor Pressure: 1 mm Hg at 3248 °F (1787 °C)
Electrical Resistivity: 9.71 μΩ/cm at 68 °F (20 °C)
Molecular Weight: 55.847
Density/Specific Gravity: 7.86 at 68 °F (20 °C)
Water Solubility: Insoluble

Appearance and Odor: Pure, solid iron is a silvery-white or gray, soft, ductile, malleable (can be rolled, hammered, or bent), slightly magnetic (becoming more so as it is alloyed; for example, steel) metal. It is available as ingots, wire, sheets, or powder. The powder form is black-gray.

Section 4. Fire and Explosion Data

Flash Point: None reported*	Autoignition Temperature: None reported*	LEL: None reported	UEL: None reported

Extinguishing Media: For small fire, use water spray, carbon dioxide (CO_2), or regular foam. For large fires, use water spray or regular foam. Apply cooling water spray to fires-exposed container sides until fire is well out. If possible with no risk, remove containers from area.
Unusual Fire or Explosion Hazards: Since finely divided iron powder is pyrophoric and ignites upon exposure to air at normal temperatures, fires and dust explosions can occur in ducts or separators used to remove the dust during grinding and polishing operations.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Fight fire from as far a distance as possible. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

*Although no flash point or autoignition temperature is reported, remember that the powder form is pyrophoric and can ignite spontaneously in air at room temperatures.

Section 5. Reactivity Data

Stability/Polymerization: Iron is stable in dry air, but readily oxidizes in moist air to form rust. Highly divided powder forms are very unstable and can ignite spontaneously in air.
Chemical Incompatibilities: Solid or powdered iron ignites or explodes on contact with acetaldehyde, ammonium peroxodisulfate, chloroformamidinium, chloric acid, ammonium nitrate, halogens, dinitrogen tetraoxide, nitryl fluoride, polystyrene, sodium acetylide, potassium dichromate, peroxyformic acid, and nitryl fluoride. Hot iron wire burns in chlorine gas and iron with water forms rust.
Conditions to Avoid: Avoid generation of iron dusts and contact with the materials listed above.
Hazardous Products of Decomposition: Thermal oxidative decomposition of iron can produce toxic iron oxide fumes.

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Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC, NTP, and OSHA do not list iron as a carcinogen although the mining of one particular ore, hematite, may be associated with an increased risk of lung cancer in miners. No other iron ores are identified specifically as a carcinogen.
Summary of Risks: Occupational exposures usually result from dust or fume inhalation during mining, ore preparation, production, and refining of the metal and its alloys. Acute and chronic toxicity can occur. Although rare, occupational toxicity by ingestion has occurred. Its effects are the same as those by ingestion of large amounts of iron tablets.
Medical Conditions Aggravated by Long-Term Exposure: Chronic respiratory diseases.
Target Organs: Eyes, respiratory tract, liver, and pancreas.
Primary Entry Routes: Eyes, inhalation, and ingestion.
Acute Effects: Inhalation may be irritating to the respiratory tract. Eye contact may cause conjunctivitis (inflammation of the eye's lining), and deposition of iron particles can leave a "rust ring" or brownish stain on the cornea. Iron's acute toxicity results primarily from accidental or suicidal ingestions (e.g., overdose of iron-containing vitamin pills). Initially, the patient may have vomiting, abdominal pain, bloody diarrhea, hematemesis (vomiting blood), lethargy, and shock. After several hours, the patient may improve, but should be observed carefully, as toxicity may progress to development of profound shock, severe acidosis (increased acidity in blood), cyanosis (bluish skin discoloration), and fever. Two to four days after exposure, liver damage may occur. Within several weeks after exposure, in several rare cases, gastrointestinal fibrosis (scarring) has occurred with obstruction of the digestive tract. Iron overdose may be fatal.
Chronic Effects: Chronic inhalation can produce mottling (spotting) of lungs (siderosis). This condition is often without symptoms and has been referred to as "benign radiopaque pneumoconiosis." Ingestion of greater than 50 to 100 mg of iron per day may result in pathological iron deposition in body tissues. Symptoms include fibrosis (scarring) of the pancreas, diabetes mellitus, and liver cirrhosis. Repeated iron ingestion can produce cardiac toxicity.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Consult poison control center.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Management of iron poisoning by ingestion is complex and beyond this MSDS's scope. Consult a medical toxicologist.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel. Isolate hazard area, deny entry, and stay upwind. Shut off all ignition sources–no flares, smoking, or flames in hazard area. Avoid dust generation by cleaning small spills with a damp mop. Since finely divided iron powder is explosive, take special care during cleanup. For large spills, flush material with a stream of water and dike for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
OSHA Designations
Listed (as iron oxide fumes) as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent any skin contact.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in a cool, dry, well-ventilated area away from flammable gases or liquids, oxidizing materials, or organic peroxides (Sec. 5).
Engineering Controls: Avoid dust inhalation. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Regularly service the ducting at grinding and polishing machines and finishing belts to maintain efficiency of exhaust ventilation and prevent explosion. Remote control operations of machinery is advisable when at all possible.

Transportation Data (49 CFR 172.101)
DOT Shipping Name: Iron mass *or* sponge, *not properly oxidized*
DOT Hazard Class: Flammable solid
ID No.: NA1383
DOT Label: Flammable solid
DOT Packaging Exceptions: None
DOT Packaging Requirements: 173.174

MSDS Collection **References:** 26, 73, 103, 124, 126, 127, 132, 136, 138, 139, 143, 146, 148, 149, 159
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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Sheet No. 765
3,3'-Dichlorobenzidine (and Its Salts)

Issued: 9/91

Section 1. Material Identification

3,3'-Dichlorobenzidine ($C_6H_3ClNH_2C_6H_3ClNH_2$) Description: Prepared from *o*-chloronitrobenzene, 3,3'-dichlorobenzidine is used solely in producing 3,3'-dichlorobenzidine dihydrochloride. 3,3'-dichlorobenzidine is encountered commercially as dihydrochloride salt because of its greater stability. 3,3'-Dichlorobenzidine dihydrochloride is used in manufacturing azo dyes, pigments for printing ink, textiles, plastics, and crayons; as a curing agent for isocyanate-terminated resins for urethane plastics; and as an intermediate for the Benzidine Yellow pigments.
Other Designations: CAS No. 0091-94-1, 3,3'-dichlorobenzidine; CAS No. 0612-83-9, 3'-dichlorobenzidine dihydrochloride; Curithane C126;® DCB; 4,4'-diamino-3,3'-dichlorobiphenyl; 4,4'-diamino-3,3'-dichlorodiphenyl; dichlorobenzidine; o,o'-dichlorobenzidine.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I -
S 2*
K 1
* Skin absorption

Genium

HMIS
H 2†
F 1
R 0
PPG‡
† Chronic Effects (Sec. 6)
‡ Sec. 8

Cautions: Avoid exposure to DCB (and its salts) since it is a *suspected human carcinogen.*

Section 2. Ingredients and Occupational Exposure Limits

3,3'-Dichlorobenzidine and its salts, ca 100%

1990 OSHA PEL*
None established

1990-91 ACGIH TLV*
None established

1990 NIOSH REL*
None established

1985-86 Toxicity Data†
Rat, oral, LD_{50}: 5250 mg/kg; toxic effects not yet reviewed
Dog, oral, TD_{Lo}: 17 g/kg administered intermittently over 7 years in a number of separate discrete doses produces tumorigenic effects including liver, kidney, ureter, and bladder (tumors)

1990 IDLH Level*
None established

* Since 3,3'-dichlorobenzidine is a suspected human carcinogen, there are no established exposure limits. Exposure in industrial processes must be minimal.
†See NIOSH, *RTECS* (DD0525000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 756 °F (402 °C)
Melting Point: 270 to 271 °F (132 to 133 °C)
pH: Weak base
Molecular Weight: 253.13
Water Solubility: Almost insoluble

Appearance and Odor: 3,3'-Dichlorobenzidine occurs as a gray or purple crystalline solid. 3,3'-Dichlorobenzidine dihydrochloride occurs as a moist colorless or white needles or crystals with a mild odor of aromatic amines.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2), water spray, or foam. For large fires, use water spray, fog, or foam.
Unusual Fire or Explosion Hazards: Fire may produce toxic fumes.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode, and full protective clothing. If feasible, move containers from fire hazard area. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Decontaminate personal protective gear and building areas prior to rehabitation.

Section 5. Reactivity Data

Stability/Polymerization: 3,3'-Dichlorobenzidine is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: None reported.
Conditions to Avoid: Avoid heating to decomposition.
Hazardous Products of Decomposition: Thermal oxidative decomposition of 3,3'-dichlorobenzidine and its salts can produce very toxic fumes of hydrochloric acid (HCl), chlorine (Cl_2), and nitrogen oxides (NO_x).

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Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, 3,3'-dichlorobenzidine is listed as an ACGIH suspected human carcinogen, and an IARC possible human carcinogen (Group 2B, inadequate human and sufficient animal evidence), an NTP anticipated human carcinogen, and an OSHA suspected cancer agent.
Summary of Risks: Although no cases of human tumors have been observed, by analogy with effects caused in animals, DCB and its salts may cause cancer in humans. Workers in the printing and graphics arts professions are at special risk .
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Bladder, liver, lung, skin, gastrointestinal (GI) tract.
Primary Entry Routes: Inhalation, skin absorption.
Acute Effects: Skin contact may cause allergic skin reactions.
Chronic Effects: Chronic exposure to DCB could cause bladder cancer in humans by analogy to animal studies. In a 30-year follow-up study of 934 workers in a benzidine manufacturing plant, there was an excess of 8 vs. 1.53 expected bladder cancers.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: If exposure occurs, decontaminate patient and then examine periodically for early tumor detection.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, and provide adequate ventilation. Cleanup personnel should wear an SCBA and full protective clothing to avoid vapor inhalation and skin contact. For small spills, use a noncombustible absorbent material to take up spilled material. Place absorbed material into appropriate, labelled (cancer-suspect agent) containers for disposal. For large spills, dike far ahead of liquid to contain for later disposal. Decontaminate spill area with a sodium hypochlorite bleach solution or an aqueous solution of 5% tetrapotassium pyrophosphate and 10% sodium ethyl hexyl sulfate. Do not release runoff to sewers or waterways. Follow applicable OSHA regulations (29 CFR 1910.120). Conduct surface analysis prior to rehabitation.
Environmental Transport: DCB bioconcentrates in fish.
Environmental Degradation: DCB undergoes rapid photooxidation in surface layers of water (half-life 90 sec) to form 3-chlorobenzidine and benzidine.
Soil Absorption/Mobility: If released on land or in water, DCB rapidly absorbs and tightly binds to soil, sediment, and particulate matter.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U073
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per Clean Water Act, Sec. 307(a), per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Fullface supplied air respirators of continuous flow or pressure demand type should be used by those employed in handling operations. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Full body protective clothing and gloves should be used by those employed in handling operations.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations at the lowest feasible limit (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Change clothing daily and discard immediately if obvious contamination occurs. Workers should shower immediately after removing contaminated clothing. Place contaminated protective clothing and equipment in impervious containers when exiting a regulated area. Segregate contaminated protective clothing so there is no direct personal contact by personnel who handle, dispose of, or clean the clothing. Shower daily before dressing in street clothes.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed, labelled (cancer-suspect agent) containers. Protect containers against physical damage.
Engineering Controls: Use engineering controls and personal protective equipment to avoid all potential exposures to 3,3'-dichlorobenzidine. Establish a regulated area where 3,3'-dichlorobenzidine is manufactured, processed, used, repackaged, released, or stored. Control all such areas in accordance with the requirements described in 29 CFR 1910.1007. Consult 29 CFR 1910.1007 for more information. Educate workers about 3,3'-dichlorobenzidine's hazards and the necessary precautions for handling this potential carcinogen. Consider a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice meticulous housekeeping and personal hygiene procedures. As well as regular monitoring, perform periodic checks on lab/work atmospheres, surfaces such as walls, floors, benches, interior of fume hoods, and air ducts to eliminate risk of contamination.
Medical Surveillance: Consider a medical surveillance program for an employee population at risk from chronic exposure. Medical screening would include initial and periodic occupational history, general physical examination, complete blood count, screening chemistries, urinalysis, possibly including urine cytologies. Medical history should include family history, exposure to other carcinogens, cigarette and alcohol exposure, and a history of chemical exposures from prior positions and through hobbies at home.

Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection **References:** 26, 38, 73, 89, 100, 103, 124, 126, 127, 132, 136, 138, 142, 143, 146, 148
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 769
o-Chlorotoluene

Issued: 9/91

Section 1. Material Identification

35

o-Chlorotoluene ($CH_3C_6H_4Cl$) **Description:** Derived by catalytic chlorination of toluene. Used as a solvent and an intermediate for organic chemicals and dyes, an insecticide, a bactericide, and a disinfectant for coccidiosis control.
Other Designations: CAS No. 0095-49-8, 2-chlorotoluene, 2-chloro-1-methylbenzene, *o*-tolyl chloride, *ortho*-chlorotoluene, 1-methyl-2-chlorobenzene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I 3
S 2
K 3

NFPA

HMIS
H 2
F 2
R 0
PPG*
* Sec. 8

Cautions: *o*-Chlorotoluene is a combustible liquid that is moderately toxic by inhalation and ingestion.

Section 2. Ingredients and Occupational Exposure Limits

o-Chlorotoluene, ca 100%

1990 OSHA PEL	1991-92 ACGIH TLV	1990 NIOSH REL	1985-86 Toxicity Data*
8-hr TWA: 250 mg/m³, 50 ppm	TWA: 259 mg/m³, 50 ppm	TWA: 250 mg/m³, 50 ppm STEL: 375 mg/m³, 75 ppm	Rat, inhalation, LC_{Lo}: 17,500 ppm produced ataxia and respiratory depression

* See NIOSH, *RTECS* (XS9000000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 320 °F (159 °C)
Melting Point: -32 °F (-35.6 °C)
Vapor Pressure: 3.6 mm Hg at 77 °F (25 °C)
Vapor Density (air = 1): 4.37
Refraction Index: 1.5268 at 68 °F (20 °C)
Molecular Weight: 126.58
Density/Specific Gravity: 1.0776 at 77 °F (25 °C)
Water Solubility: Slightly soluble, 89 mg/l at 77 °F (25 °C)
Other Solubilities: Soluble in alcohol, acetone, benzene, chloroform, carbon tetrachloride, ether, and *n*-heptane

Appearance and Odor: Colorless liquid with pungent, irritating odor and an odor threshold of ~0.05 ppm.

Section 4. Fire and Explosion Data

Flash Point: 96.1 °F (35.6 °C)	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: *o*-Chlorotoluene is a flammable liquid that heat, sparks, or flames may ignite. For small fires, use dry chemical, carbon dioxide (CO_2), water spray, or regular foam. For large fires, use water spray, fog, or regular foam. If possible without risk, remove container from fire area.
Unusual Fire or Explosion Hazards: Use care when applying water to fire, since generation of any steam can be volatile in contact with o-chlorotoluene. Vapors may travel to an ignition source and flash back. Containers may explode in heat of fire. *o*-Chlorotoluene poses a potential explosion hazard indoors, outdoors, and in sewers.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Apply cooling water to sides of fire-exposed containers until fire is well out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Withdraw from area immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Isolate area for 1/2 mile in all directions if fire involves tank truck or rail car. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: *o*-Chlorotoluene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: None reported.
Conditions to Avoid: Avoid buildup of vapors and generation of excess heat.
Hazardous Products of Decomposition: Thermal oxidative decomposition of *o*-chlorotoluene can produce carbon dioxide (CO_2) and toxic chlorine fumes.

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Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC, NTP, and OSHA do not list *o*-chlorotoluene as a carcinogen.
Summary of Risks: *o*-Chlorotoluene is irritating to the eyes, skin, and respiratory system.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Eyes, skin, respiratory system.
Primary Entry Routes: Inhalation, ingestion, and skin contact.
Acute Effects: *o*-Chlorotoluene is irritating to the eyes, skin, and respiratory system. Specific symptoms are not documented.
Chronic Effects: None reported.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Treatment is symptomatic and supportive.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources—no flames, flares, or smoking, allowed in hazard area. If possible without risk, stop leak. Water spray may reduce vapor, but it may not prevent ignition in closed spaces. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. For large spills, dike far ahead of liquid spill for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Transport: When released into the atmosphere, *o*-chlorotoluene is chemically removed by photochemically generated hydroxyl radicals; its half-life in the air is 8.4 days. *o*-Chlorotoluene volatilizes from water with a 3.4-hr half-life.
Soil Absorption/Mobility: *o*-Chlorotoluene should have low-to-moderate mobility and should volatilize readily from soil.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.21): Characteristic of ignitability
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Select the respirator based on its suitability to provide adequate worker protection for the given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent repeated or prolonged skin contact.
Ventilation: Provide general and local explosion-proof exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in a cool, dry, well-ventilated area away from sources of ignition.
Engineering Controls: To minimize potential hazards, use adequate ventilation and wherever possible, enclose and electrically ground all equipment used in the manufacture, use, and storage of *o*-chlorotoluene.
Other Precautions: Consider a respiratory protection program that includes regular training, maintenance, inspection, and evaluation as well as preplacement and periodic medical examinations of exposed workers. Practice good personal hygiene and housekeeping procedures.

Transportation Data (49 CFR 172.102)
IMO Shipping Name: Chlorotoluene (*o*-, *m*-, *p*-)
IMO Hazard Class: 3.3
ID No.: UN2238
IMO Label: Flammable Liquid
IMDG Packaging Group: III

MSDS Collection **References:** 89, 124, 126, 127, 132, 136, 138, 143, 146, 153, 159, 161
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MD, MPH; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 789
Cyanide

Issued: 11/91

Section 1. Material Identification

Cyanide (CN^-) Description: Derived by combining a carbon ion with a nitride ion. Used in rat and pest poisons, silver and metal polishes, photographic solutions, fumigating products, and electroplating solutions. Cyanide may also be liberated in burning of plastics, natural fabrics (wool or silk), polyurethane bedding or furniture, acrylic baths, nylon carpets, and melamine resin insulation.

Other Designations: CAS No. 57-12-5, carbon nitride ion, cyanide anion, isocyanide.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I 4
S 2
K 1

Genium

HMIS
H 4
F 1
R 1
PPG*
* Sec. 8

Cautions: Cyanide is severely toxic by all routes of entry and its lethal dose is an estimated 1 µg/ml. Take necessary precautions to avoid all possible exposure to this material.

Section 2. Ingredients and Occupational Exposure Limits

Cyanide, ca 100%

1990 OSHA PEL (Skin)
STEL: 4.7 ppm, 5 mg/m³, as hydrogen cyanide (gas)

1991-92 ACGIH TLV (Skin)
Ceiling: 10 ppm, 11 mg/m³, as hydrogen cyanide (gas)

1990 DFG (Germany) MAK (*Danger of cutaneous absorption*)
TWA: 10 ppm, 11mg/m³ as hydrogen cyanide (gas)

1990 IDLH Level
50 mg/m³

1990 NIOSH REL (Skin)
STEL: 4.7 ppm, 5 mg/m³ as hydrogen cyanide (gas)

1985-86 Toxicity Data*
Mouse, intraperitoneal, LD_{50}: 3 mg/kg; toxic effects not yet reviewed

* See NIOSH, *RTECS* (GS7175000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: Varies with specific CN^- compound
Melting Point: Varies with specific CN^- compound
Molecular Weight: 26.02
Density: Varies with specific CN^- compound
Water Solubility: Varies with specific CN^- compound

Appearance and Odor: Varies with specific CN^- compound, but usually has an almond odor.

Section 4. Fire and Explosion Data

Flash Point: None reported	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: Cyanide is combustible. For small fires, use dry chemical, water spray or foam. *Do not use carbon dioxide (CO_2)!* For large fires, use water spray, fog, or regular foam. *Do not scatter* material with more water than needed to extinguish fire.

Unusual Fire or Explosion Hazards: Combustible by chemical reaction with heat, moisture, or acid. Many cyanides readily evolve hydrogen cyanide (HCN), a toxic flammable gas.

Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing *is ineffective* for fires involving cyanide. Wear chemical protective clothing that the shipper or manufacturer specifically recommends. If possible without risk, remove container from fire area. Fight fire from maximum distance. Stay away from ends of tanks. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Remove and isolate contaminated clothing at the site.

Section 5. Reactivity Data

Stability/Polymerization: Cyanide is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Cyanide may react violently with hypochlorite solutions at pH 10 to 10.3, is explosive with nitrites if heated above 450 °C, and is incompatible with chlorates, fluorine, magnesium, nitrates, and all inorganic acids.

Conditions to Avoid: Avoid exposure to heat and contact with incompatibles.

Hazardous Products of Decomposition: Thermal oxidative decomposition of cyanide can produce carbon dioxide and toxic, flammable vapors of CN^-.

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC, NTP, and OSHA do not list cyanide as a carcinogen.

Summary of Risks: Cyanide is a potent, fast-acting, chemical asphyxiant (material which causes pulse and breathing obstruction) that prevents tissue utilization of oxygen by inhibiting the enzyme involved (cytochrome oxidase). Death can occur within seconds to minutes after inhalation of some cyanide gases, and may take as long as an hour after ingestion of a large amount of a cyanide salt due to a slower absorption. Toxicity is dependent on the form of cyanide the victim is exposed to. Mortality from acute exposures is high, but recovery is generally complete in nonfatal cases.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Continue next page

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Section 6. Health Hazard Data, *continued*

Target Organs: Brain, heart, lungs, skin, blood.
Primary Entry Routes: Inhalation, ingestion, skin absorption.
Acute Effects: Inhalation of cyanide gases may cause rapid toxicity where the victim may only have time to utter a warning cry before succumbing to unconsciousness caused by asphyxiation. If exposure is small there may be a weak, rapid, irregular heartbeat with bright-pink coloration of the skin due to high oxyhemoglobin content in the veins before person loses consciousness. A telltale sign of inhalation or ingestion is the odor of bitter almonds on the breath, however up to half the population is genetically unable to detect this smell. Dialated pupils are common in severe poisonings. Contact with broken skin can cause cyanide absorption into the bloodstream. Cyanide ingestion can cause a bitter, burning taste, salivation, nausea, vomiting, anxiety, confusion, vertigo (dizziness), giddiness, sensation of stiffness in the lower jaw, and dyspnea (difficult respiration). In severe cases symptoms could progress to convulsions, paralysis, coma, cardiac arrhythmias, followed by death due to respiratory failure.
Chronic Effects: Chronic skin contact may cause cyanide rash, characterized by itching, and macular (blotches), papular (small, solid, conical, elevation of the skin), and vesicular (blister-like) eruptions. Chronic cyanide inhalation may cause appetite loss, headache, weakness, nausea, dizziness, and symptoms of irritation of the upper respiratory tract and eyes. Other symptoms of chronic exposure include goiter, B12 and folate abnormalities, chest discomfort, epistaxis (nose bleed), poor appetite and sleeping, and functional changes in hearing.
FIRST AID: *Emergency personnel should protect against contamination!*
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Speed is extremely important. Rinse with flooding amounts of water for at least 15 min. Wash exposed area *extremely thoroughly* with soap and water. If irritation and pain persist, consult a physician.
Inhalation: Remove exposed person to fresh air and immediately begin administering 100% oxygen. Avoid mouth-to-mouth resuscitaton during CPR to prevent self-poisonings.
Ingestion: Obtain and prepare the Lilly cyanide antidote kit [Eli Lilly Co. (Stock No. M76)] for use in symptomatic patients. Never give anything by mouth to an unconscious or convulsing person. Do not induce vomiting with Ipecac syrup. Consider gastric lavage. Activated charcoal is said to be ineffective.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: If the victim is unconscious, bradycardia and absence of cyanosis may be key diagnostic signs. Consider administration of amyl nitrite followed by sodium nitrite and sodium thiosulfate (antidote kit). Consider use of 100% oxygen.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources—no flames, flares, or smoking in hazard area. Cleanup personnel should wear fully encapsulating, vapor-protective clothing for spills or leaks without fire. For small dry spills, carefully scoop into clean, dry, suitable container and cover loosely. For small solution spill, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. For large spills, dike far ahead of solution spills for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): Hazardous Waste No. P030
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity: *An RQ is not being assigned to the general class* [* per Clean Water Act, Sec. 307(a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Select the respirator based on its suitability provide adequate worker protection for the given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA with a full facepiece operated in pressure-demand or other positive-pressure mode. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent repeated or prolonged skin contact.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PEL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics. Cyanide detoxifying kits and instructions should be available in use areas. Instruct employees working in these areas on how and when to use these kits.

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in tightly closed and properly labeled containers in cool, dry, well-ventilated area away from heat and incompatibles.
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control hazardous airborne contaminants and to maintain concentrations at the lowest practical level.
Other Precautions: If respirators are used, implement a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Consider preplacement and periodic medical examinations of exposed workers that emphasize the heart, blood, and respiratory system.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Cyanide *or* cyanide mixture, dry
DOT Hazard Class: Poison B
ID No.: UN1588
DOT Label: Poison
DOT Packaging Exceptions: 173.364
DOT Packaging Requirements: 173.370

IMO Shipping Name: Cyanides, inorganic, n.o.s.
IMO Hazard Class: 6.1
ID No.: UN1588
IMO Label: Poison
IMDG Packaging Group: I/II; Stow 'away from' acids

MSDS Collection References: 73, 101, 103, 126, 127, 136, 143, 146, 148, 153, 159, 161, 163
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Section 1. Material Identification

Hexachlorocyclopentadiene (C_5Cl_6) Description: Derived by chlorinating cyclopentadiene, followed by catalytic chlorination over phosphorus pentachloride or arsenic oxide and then thermally dechlorinating. Used as an intermediate for resins, dyes, pesticides, fungicides, flame retardants and pharmaceuticals; as an agricultural fumigant; and in shock-proof plastics, acids, esters, ketones, and fluorocarbons.
Other Designations: CAS No. 77-47-4; C-56; 1,3-cyclopentadiene,1,2,3,4,5,5-hexachloro; Graphlox; NCI-C55607; PCL; perchlorocyclopentadiene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

R 1
I 4
S 4*
K 1
* Skin absorption

Genium

HMIS
H 2
F 0
R 1
PPG†
† Sec. 8

Cautions: Hexachlorocyclopentadiene is a corrosive, highly toxic material to the skin, eyes, mucous membranes, and especially the lungs. It is considered an experimental teratogen.

Section 2. Ingredients and Occupational Exposure Limits

Hexachlorocyclopentadiene, ca 100%*

1990 OSHA PEL
8-hr TWA: 0.01 ppm (0.1 mg/m^3)

1991-92 ACGIH TLV
TWA: 0.01 ppm (0.11 mg/m^3)

1990 NIOSH REL
8-hr TWA: 0.01 ppm (0.1 mg/m^3)

1990 DFG (Germany) MAK
None established

1985-86 Toxicity Data†
Rat, oral, LD_{50}: 113 mg/kg, toxic effects not yet reviewed
Rat, inhalation, LC_{50}: 1600 ppb/4 hr caused drowsiness and lung changes
Rabbit, oral, TD_{Lo}: 975 mg/kg administered from 6 to 18 days of pregnancy caused developmental abnormalities of musculoskeletal system
Rabbit, eye: 20 mg/24 hr produced moderate irritation
Monkey, skin: 10 mg produced severe irritation

* Technical grade usually contains manufacturing contaminants such as hexachlorobenzene and octachlorocyclopentene.
† See NIOSH, *RTECS* (GY1225000), for additional irritation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 462.2 °F (239 °C)
Melting Point: 49.3 °F (9.6 °C)
Vapor Pressure: 0.08 mm Hg at 77 °F (25 °C), 1 mm Hg at 140 °F (60 °C)
Vapor Density (air = 1): 9.42
Saturated Vapor Concentration: 107 ppm
Molecular Weight: 272.75
Density: 1.717 at 59 °F (15/15 °C)
Water Solubility: Virtually insoluble, 2 ppm at 77 °F (25°F)
Other Solubilities: Soluble in acetone, carbon tetrachloride, hexane, and methanol
Refraction Index: 1.563 at 77 °F (25 °C)

Appearance and Odor: Dense, oily, pale-yellow to amber liquid. It has a pungent odor that is faint at 0.15 ppm and pronounced at 0.33 ppm.

Section 4. Fire and Explosion Data

Flash Point: Nonflammable, OC	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: For small fires, use dry chemical or regular foam. For large fires, use fog or regular foam. *Do not* use water spray unless no other extinguishing agent is available. Water reacts with hexachlorocyclopentadiene to form hydrochloric acid and explosive hydrogen gas that can collect in tight spaces.
Unusual Fire or Explosion Hazards: Container may explode violently in heat of fire. Toxic hydrogen chloride (HCl), chloride (Cl^-), phosgene ($COCl_2$), and carbon monoxide (CO) fumes may evolve in fire.
Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing *is ineffective* for fires involving hexachlorocyclopentadiene! Wear chemically protective clothing specifically recommended by the shipper or manufacturer. If possible without risk, remove container from fire area. Fight fire from maximum distance. Stay away from ends of tanks. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Hexachlorocyclopentadiene is stable in dry, closed containers at room temperature. In the presence of moisture it undergoes a chemical change to form explosive hydrogen gas (especially in enclosed areas) and hydrochloric acid (slowly). Hazardous polymerization cannot occur.
Chemical Incompatibilities: Hexachlorocyclopentadiene may explode upon contact with sodium and can corrode iron and other metals in the presence of moisture.
Conditions to Avoid: Contact with sodium and any form of moisture.
Hazardous Products of Decomposition: Thermal oxidative decomposition of hexachlorocyclopentadiene can produce carbon dioxide (CO_2) and toxic chloride (Cl^-) fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[142] and OSHA[164] do not list hexachlorocyclopentadiene as a carcinogen.
Summary of Risks: Hexachlorocyclopentadiene vapor inhalation is highly irritating to lungs. Due to its unmistakable odor and subsequent irritating and lacrimating (secretion of tears) ability, prolonged exposure to hexachlorocyclopentadiene is intolerable and probably prevents further injury. Skin irritation can occur from direct contact or exposure to vapors. If ingested, the probable human lethal dose is 50 to 500 mg/kg.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Eyes, lungs, skin.
Primary Entry Routes: Inhalation, skin contact/absorption.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Acute Effects: The major target organ of hexachlorocyclopentadiene exposure is the lungs, regardless of exposure route. Vapor inhalation can cause cough, dyspnea (difficulty breathing), chest discomfort, headache, bronchitis (inflammation of bronchial tubes), bronchiolitis (inflammation of bronchioles), and pulmonary edema (fluid in lungs). There are some reports of momentary confusion and memory loss. Skin contact or absorption can produce local irritation as well as symptoms associated with vapor inhalation. Conjunctivitis (inflammation of mucous membranes of the eyelids) may result from vapor exposure. In one reported incident at a sewage treatment plant, upon exposure to an undetermined concentration of hexachlorocyclopentadiene, workers experienced eye irritation (59%), headache (45%), and throat irritation (27%). After three days, medical examination showed proteinuria (protein in urine) which was not present three weeks later. There is the possibility of late injury to the liver, kidney, and heart by any route of exposure.
Chronic Effects: Chronic exposure is likely to damage the liver, kidney, and nervous system. Chloro-acne may also occur after repeated exposures.
FIRST AID
Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.
Inhalation: Remove exposed person to fresh air, administer 100% humidified supplemental oxygen and support breathing as needed.
Ingestion: Unlikely. Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Since effects may be delayed, keep victim under observation. Consider obtaining baseline arterial blood gases in victims with significant exposure or respiratory irritation.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel should wear fully encapsulating, vapor-protective clothing. Use a water spray to reduce vapors but do not spray directly on spilled material since hydrogen gas and hydrochloric acid may be generated. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in clean, dry containers for disposal or reclamation. For large spills, dike far ahead of liquid spill and await disposal or reclamation. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Transport: When released into the atmosphere, hexachlorocyclopentadiene should exist almost entirely in the vapor phase. Photolysis (chemical decomposition by radiant energy) is likely to be the dominant removal mechanism. Hexachlorocyclopentadiene is usually immobile in soil but becomes highly mobile when leached with organic solvents. In water, hexachlorocyclopentadiene is degraded by photolysis and hydrolysis.
Environmental Degradation: Ecotoxicity Values: LC_{50} (fathead minnows, early juvenile), 6.7 µg/L/30 days; LC_{50} (fathead minnows, larval), 7 µg/L/96 hr. Bioassays indicate that ~1-ppm concentration of hexachlorocyclopentadiene is acutely toxic to fish.
Soil Absorption/Mobility: Hexachlorocyclopentadiene's absorption capacity correlates with the soil's total organic carbon content.
Disposal: *Do not* landfill hexachlorocyclopentadiene with organic solvents because of leaching potential. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U130
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 10 lb (4.54 kg) [* per RCRA, Sec. 3001; CWA, Sec. 307(a) and 311(b)(4)]
Listed as a SARA Extremely Hazardous Substance (40 CFR 355)
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. Protective gear made from natural rubber, neoprene, and polyvinyl chloride *is not* recommended. Because butyl rubber, nitrile rubber, polyvinyl alcohol, and fluorocarbon rubber have a breakthrough time >8 hr, they are better choices.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in cool, dry, well-ventilated area away from incompatibles (Sec. 5).
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level.
Administrative Controls: Consider preplacement and periodic medical examinations of exposed workers emphasizing the skin and lungs.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Hexachlorocyclopentadiene
DOT Hazard Class: Corrosive material
ID No.: UN2646
DOT Label: Corrosive
DOT Packaging Exceptions: 173.244
DOT Packaging Requirements: 173.245

IMO Shipping Name: Hexachlorocyclopentadiene
IMO Hazard Class: 6.1
ID No.: UN2646
IMO Label: Poison
IMDG Packaging Group: I

MSDS Collection **References:** 73, 89, 103, 126, 127, 132, 133, 136, 143, 149, 152, 162-164
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Sheet No. 801
Hexac lorobutadiene

Issued: 3/92

Section 1. Material Identification

Hexachlorobutadiene (Cl_2C:$CClCCl$:CCl_2) **Description:** Derived as a by-product of chlorination of various hydrocarbons such as tetrachloroethylene, trichloroethylene, and carbontetrachloride. Used as a solvent for elastomers, a heat transfer liquid, a transformer and hydraulic fluid, a wash liquor for removing C_4 and higher hydrocarbons, a chemical intermediate for fluorinated lubricants and rubber compounds, and a fluid for gyroscopes; and in pesticides.
Other Designations: CAS No. 87-68-3, Dolen-Pur, HCBD, hexachloro-1,3-butadiene, perchlorobutadiene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I 4
S 2*
K 1
* Skin absorption

NFPA

HMIS
H 2
F 1
R 1
PPG†
† Sec. 8

Cautions: Hexachlorobutadiene is toxic by inhalation, ingestion, and skin absorption, and is an experimental carcinogen and mutagen. This liquid is slightly combustible.

Section 2. Ingredients and Occupational Exposure Limits

Hexachlorobutadiene, ca 98%

1990 OSHA PEL
8-hr TWA: 0.02 ppm (0.24 mg/m³)

1990 DFG (Germany) MAK
Suspected Carcinogen

1985-86 Toxicity Data*
Rat, oral, LD_{50}: 90 mg/kg; toxic effects not yet reviewed
Mouse, inhalation, LC_{Lo}: 235 ppm/4 hr; toxic effects not yet reviewed
Rat, oral, TD_{Lo}: 15 g/kg given continuously over a 2-year period produced kidney tumors and other effects on ureter and bladder
Rabbit, skin: 810 mg applied for 24 hr produced moderate irritation

1991-92 ACGIH TLV
TWA: 0.02 ppm (0.21 mg/m³)

1990 NIOSH REL
None established

* See NIOSH, *RTECS* (EJ0700000), for additional irritation, mutation, reproductivity, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point Range: 410 to 428 °F (210 to 220 °C)
Freezing Point Range: -2.2 to -7.6 °F (-19 to -22 °C)
Vapor Pressure: 22 mm Hg at 212 °F (100 °C), 500 mm Hg at 392 °F (200 °C)
Vapor Density (air = 1): 8.99
Refraction Index: 1.5542 at 68 °F (20 °C)
Molecular Weight: 260.74
Density: 1.675 at 59.9 °F (15.5 °C)
Water Solubility: Insoluble
Other Solubilities: Soluble in alcohol and ether and miscible with many resins
% in Saturated Air: 0.037 at 77 °F (25 °C)
Viscosity: 2.447 cP at 99.86 °F (37.7 °C), 1.131 cP at 210.02 °F (98.9 °C)

Appearance and Odor: Clear, colorless, heavy liquid with a mild turpentine odor. Half the people questioned could detect 1 ppm. *Caution!* Detection of 1 ppm is inadequate for preventing overexposure.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** 1130 °F (610 °C)	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Hexachlorobutadiene is slightly combustible. For small fires, use dry chemical, water spray, or regular foam. For large fires, use water spray, fog, or regular foam. *Do not scatter fire* with more water than necessary to put out fire.
Unusual Fire or Explosion Hazards: Container may explode in heat of fire.
Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. If possible without risk, remove container from fire. Fight fire from maximum distance. Stay away from ends of tanks. Structural firefighters' protective clothing is ineffective for fires involving hexachlorobutadiene. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Heavy vapors from a fire may accumulate in low areas (pits, etc.) and remain hazardous after the fire is extinguished.

Section 5. Reactivity Data

Stability/Polymerization: Hexachlorobutadiene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: None reported.
Conditions to Avoid: Generation of vapors and exposure to excessive heat.
Hazardous Products of Decomposition: Thermal oxidative decomposition of hexachlorobutadiene can produce carbon dioxide (CO_2) and toxic chloride fumes (Cl^-).

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, these groups classify hexachlorobutadiene: IARC (Group 3), NIOSH (Suspected Carcinogen), and ACGIH (A2, Suspected Human Carcinogen).
Summary of Risks: Hexachlorobutadiene is a NIOSH-suspected carcinogen, potentially causing kidney and lung cancer. Most available toxicity data are based on animal studies. According to these studies, a 0.13-ppm air concentration has no effect on humans, and 1.3 ppm produces reversible changes. In the one human toxicity report found, 205 vineyard workers exposed seasonally to hexachlorobutadiene at 0.8 to 30 mg/m³

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Section 6. Health Hazard Data, *continued*

and polychlorobutane-80 at 0.12 to 6.7 mg/m³ showed a number of toxic effects that led to hypotension, cardiac disease, nervous function disturbances, chronic bronchitis, and hepatitis.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Kidney and liver (in animals).
Primary Entry Routes: Inhalation, ingestion, and skin absorption.
Acute Effects: Based on animal data and the one human study, exposure to hexachlorobutadiene could cause irritation of eyes, nose, throat, and respiratory tract, and kidney and nervous system damage.
Chronic Effects: Exposure to hexachlorobutadiene could possibly lead to cardiac disease, chronic bronchitis, and hepatitis.
FIRST AID
Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly closed. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Consult a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Consider monitoring acutely and chronically exposed patient for renal damage. Since at least some toxicity is presumed reversible, use supportive care.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Prepare a spill control plan. Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources—no flames, flares, or smoking in hazard area. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for later disposal. For large spills, dike far ahead of liquid spills for later disposal. Cleanup personnel should wear fully encapsulating, vapor-protective clothing to prevent inhalation and skin exposure. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Transportation: When released into the atmosphere, hexachlorobutadiene reacts with hydroxyl radicals and ozone and has a half-life of 3.24 hr. HCDB should biodegrade in natural waters since 100% degradation occurred in 7 days in an aerobic bath culture. Its estimated half-life in river water is 3 to 30 days, and 30 to 300 days in lake and groundwater.
Environmental Degradation: Ecotoxicity values: fathead minnow, LC_{50}, 0.09 mg/L/96 hr; *Poecilia reticula* (guppy), LC_{50}, 0.4 ppm/14 days.
Soil Absorption/Mobility: Hexachlorobutadiene absorbs strongly to soil and does not rapidly migrate, but moves more rapidly in sandy soils.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U128
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 1 lb (0.454 kg) [* per RCRA, Sec. 3001 and Clean Water Act, Sec. 307(a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for the given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment. Disposable outer garments may be a preferable alternative to prevent employee exposure.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in cool, dry, well-ventilated area away from strong heat sources.
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control the airborne contaminants and to maintain concentrations at the lowest practical level
Administrative Controls: Consider preplacement and periodic medical examinations of exposed workers. Include urinary excretion of coproporphyrins in medical exams. Training for hazardous communication is very important and workers should be educated about safe handling of a suspected carcinogen.
Transportation Data (49 CFR 172.102)
IMO Shipping Name: Hexachlorobutadiene
ID No.: UN2279
IMO Hazard Class: 6.1
IMO Label: St. Andrews
IMDG Packaging Group: III

MSDS Collection **References:** 73, 89, 103, 127, 132, 136, 142, 153, 159, 161-164
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 811
2,4-Dinitrotoluene

Issued: 3/92

Section 1. Material Identification

37

2,4-Dinitrotoluene [$C_6H_3CH_3(NO_2)_2$] Description: The most important isomer of dinitrotoluene derived by nitration of toluene with nitric acid in the presence of concentrated sulfuric acid to yield about 80% 2,4- and 20% 2,6-isomers from which the 2,4-isomer is not usually separated. Used in manufacturing explosives and dyes, in inorganic synthesis, as a chemical intermediate, a plasticizer, and a modifier for smokeless powders in the munitions industry.
Other Designations: CAS No. 121-14-2, (2,4-dinitrotoluene); CAS No. 25321-14-6 (all isomers), DNT, dinitrotoluol, methyldinitrobenzene, NCI-CO1865.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(™) for a suppliers list.

R 3
I 3
S 3*
K 2
* Skin absorption

NFPA
1
3 3
-

HMIS
H 3
F 2
R 3
PPG*
* Sec. 8

Cautions: 2,4-Dinitrotoluene is combustible and explosive. This material is highly toxic by skin absorption, inhalation, and ingestion.

Section 2. Ingredients and Occupational Exposure Limits

2,4-Dinitrotoluene, ca 80% 2,4- and 20% 2,6-, with <5% other isomers

1990 OSHA PEL (Skin)
8-hr TWA: 1.5 mg/m³

1990 IDLH Level
200 mg/m³, *all isomers. Treat as a potential human carcinogen.*

1990 NIOSH REL (Skin)
TWA: 1.5 mg/m³, *all isomers**

1991-92 ACGIH TLV (Skin)†
TWA: 1.5 mg/m³, *all isomers*

1990 DFG (Germany) MAK
Danger of cutaneous absorption
MAK-A2

1985-86 Toxicity Data‡
Rat, oral, LD_{50}: 268 mg/kg; toxic effects not yet reviewed
Rat, oral, TD_{Lo}: 2620 mg/kg administered for 78 continuous weeks caused skin and appendage tumors
Rat, oral, TD_{Lo}: 3094 mg/kg administered to a 13-week-old male produced effects on fertility (pre-implantation mortality)

* *NIOSH recommends controlling potential carcinogens at the lowest possible level.*
† Notice of intended change to 0.15 mg/m³
‡ See NIOSH, *RTECS* (XT1575000), for additional irritation, mutation, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 482 °F (250 °C)
Melting Point: 158 °F (70 °C); decomposes spontaneously at 536 °F (280 °C)
Vapor Pressure: 1 mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 6.27
Refraction Index: 1.442
Molecular Weight: 182.14
Specific Gravity: 1.3 *liquid*, 1.5 *solid* at 68 °F (20 °C)
Water Solubility: Insoluble
Other Solubilities: Soluble in alcohol, acetone, benzene, carbon disulfide, ether, and pyridine

Appearance and Odor: Orange to yellow crystalline solid or liquid with a slight odor.

Section 4. Fire and Explosion Data

Flash Point: 404 °F (207 °C), CC	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2), water spray, or regular foam. For large fires, use water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: 2,4-Dinitrotoluene is combustible and can become highly explosive when exposed to heat, friction, or contamination. 2,4-Dinitrotoluene's explosive energy is approximately 85% of TNT (a well-known, powerful explosive). Closed containers may rupture violently when heated. DNT decomposes spontaneously at 482 °F (250 °C, anaerobic) and 536 °F (280 °C, self-sustaining) and causes an explosion if confined. Contamination of DNT with organic materials lowers the decomposition temperature and increases the risk of explosion.
Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is *ineffective* for fires involving DNT. Use extreme caution and fight fire from as far away as possible. Apply cooling water to container sides until long after fire is extinguished. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: 2,4-Dinitrotoluene is explosive when exposed to heat, friction, or contamination. It can be detonated but only by a very strong initiator. DNT is slightly sensitive to impact shock, with the liquid form less so than the solid form.
Chemical Incompatibilities: 2,4-Dinitrotoluene is incompatible with organic materials; strong reducing agents such as sodium sulphide, zinc powder, sodium hyposulphite, and metallic hydrides; strong oxidizing agents such as bichromates, peroxides, and chlorates (especially during transit); caustics; and metals such as tin and zinc. DNT corrodes some forms of plastics, rubber, and coatings.
Conditions to Avoid: Exposure to heat, friction, and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of 2,4-dinitrotoluene can produce carbon dioxide (CO_2) and toxic nitrogen oxides (NO_x).

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, NIOSH recommends treating dinitrotoluene as a potential human carcinogen. The ACGIH and Germany (DFG) list it as Class A2 (probably carcinogenic to humans) and MAK-A2 (unmistakably carcinogenic in animals only), respectively. However, neither NIOSH, ACGIH, or MAK specify *which* or *how many* isomers are involved.
Summary of Risks: Highly toxic 2,4-dinitrotoluene is dangerous through all routes of human exposure. Skin absorption is more prevalent than inhalation (due to low vapor pressure) and ingestion. Cyanosis and anemia are the usual manifestations of exposure.
Medical Conditions Aggravated by Long-Term Exposure: Persons with blood disorders may be at increased risk.
Target Organs: Blood, liver, central nervous (CNS) and cardiovascular (CVS) systems.
Primary Entry Routes: Skin absorption, inhalation, ingestion.
Acute Effects: Skin absorption and inhalation cause many of the same effects. The major effect of exposure to DNT is cyanosis (a purplish discoloration of skin and mucous membranes due to lack of oxygenated blood) which occurs when methemoglobin (brownish blood pigment of the blood that cannot

Continue on next page

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Section 6. Health Hazard Data, *continued*

combine reversibly to molecular oxygen) concentration in the blood reaches 15% or more. Other possible symptoms include headache, irritability, dizziness, weakness, nausea, vomiting, dyspnea (difficulty in breathing), drowsiness, and unconsciousness. If treatment is not prompt, death may occur usually by cardiovascular collapse. Ingestion can cause irritation of mouth and stomach, stomach cramps, and diarrhea. In addition to absorption symptoms, skin contact can cause irritation, small blisters, redness, swelling, ulceration, and necrosis (death of living tissue). Contact with eyes may produce irritation, redness and swelling of eyelids, pain on exposure to light, and severe eye damage. If molten, 2,4-dinitrotoluene can cause thermal burns. Ingestion of alcohol at time of exposure can increase an individual's susceptibility to toxicity.

Chronic Effects: Repeated or prolonged exposure to DNT may cause anemia (a deficiency in red blood cells, hemoglobin, or both). 2,4-Dinitrotoluene affects the liver's drug-metabolizing enzymes and is a liver mutagen and carcinogen in rodents.

FIRST AID *Emergency personnel should protect against contamination.*

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* let victim rub or keep eyes tightly shut. Consult a physician immediately.

Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash entire body from head to foot with soap and water. Pay special attention to the hair, scalp, finger and toenails, nostrils, and ear canals. Repeat skin cleansing if the methemoglobin concentration appears to rise after 3 to 4 hr. Carefully dispose of contaminated clothing.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Consult a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Determine the methemoglobin concentration in the blood every 3 to 6 hr. Urine excretion of dinitrotoluene in excess of 25 mg/L of urine indicates significant absorption. Consider giving intravenously 10 mL of 1% methylene blue solution at or below a 2-mL/min rate for victims with methemoglobin levels above 20%. Watch patient for 48 hr after apparent recovery to detect relapsing cyanosis and advanced anemia.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources—no flames, flares, or smoking in hazard area. Cleanup personnel should wear fully encapsulating vapor-protective clothing for spills with no fire. Use a water spray to reduce vapors. For small spills, carefully place in suitable, clean, dry containers (steel drums are preferred). Remove containers from area. For large spills, flush area with hot water to remove solid DNT and contain any liquid runoff. Cool and settle solid for disposal in steel drums. Follow applicable OSHA regulations (29 CFR 1910.120).

Environmental Transport: DNT released into water absorbs slightly to sediments and suspended solids with an estimated half-life of 438 days. When released into the atmosphere, DNT has an estimated half-life of 8 hr.

Soil Absorption/Mobility: DNT is slightly mobile in soil.

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U105

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 10 lb (4.54 kg) [* per RCRA, Sec. 3001, Clean Water Act, Sec. 311(b)(4), and Clean Water Act, Sec. 307(a)]

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective face shields (8-in. minimum), per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, cleaning, and convenient, sanitary storage areas.

Other: Wear chemically protective gloves, boots, aprons, and gauntlets (butyl rubber is the most effective material for protective clothing) to prevent all skin contact.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Separate contaminated clothing so that personnel who handle, dispose of, or clean it have no direct contact with it. Remove this material from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in cool, dry, well-ventilated area away from incompatibles. DNT is normally stored as a molten liquid; be sure to keep hot water coils lower than 194 °F (90 °C).

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control the airborne contaminants and to maintain concentrations at the lowest possible level. Totally enclosed equipment systems are preferred. Be aware of mist escaping from hot charges, leaking lines, steaming operations, and hot drainage ditches because they are sources of serious skin exposure and worker environment contamination.

Administrative Controls: Suggested measures of protection include respiratory protection, job rotation, exposure time limitations, and use of protective clothing and whole body protection. Consider preplacement and periodic medical examinations of exposed workers that include blood and urine analysis, and liver function tests.

Transportation Data (49 CFR 172.102)

IMO Shipping Name: Dinitrotoluenes, solid; Dinitrotoluenes, molten

IMO Label: Poison; Poison

IMO Hazard Class: 6.1; 6.1

IMDG Packaging Group: II; II

ID No.: UN1600; UN2038

MSDS Collection **References:** 26, 38, 73, 89, 100, 101, 103, 126, 127, 136, 139, 140, 142, 148, 149, 153, 159, 162, 163, 164

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 820
Methylcyclohexane

Issued: 6/92

Section 1. Material Identification

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Methylcyclohexane [$CH_2(CH_2)_4CHCH_3$] Description: Occurs in certain crude petroleum oils, and is separated by distillation. Also derived by hydrogenation of toluene, acidic hydrocracking of polycyclic aromatics, or reaction between benzene and methane at high temperatures. There are three grades of methylcyclohexane: technical-95%, 99%, and research. Used as a solvent for cellulose ethers and an intermediate in organic synthesis.

Other Designations: CAS No. 108-87-2, cyclohexylmethane, hexahydrotoluene, Sextone B, toluene hexahydride.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I 2
S 2
K 4

NFPA

HMIS
H 2
F 3
R 0
PPG*
* Sec. 8

Cautions: Methylcyclohexane produces narcotic-like effects through inhalation and is an eye and skin irritant. It is highly volatile, flammable, and poses a vapor explosion hazard.

Section 2. Ingredients and Occupational Exposure Limits

Methylcyclohexane, ca 95 to 99%

1991 OSHA PEL
8-hr TWA: 400 ppm (1600 mg/m^3)

1991-92 ACGIH TLV
TWA: 400 ppm (1610 mg/m^3)

1990 DFG (Germany) MAKs
500 ppm (2000 mg/m^3)
Peak Exposure Limit: 1000 ppm/30 min average value/4 per shift
Half-life: <2 hr

1990 IDLH Level
10,000 ppm

1990 NIOSH REL
TWA: 400 ppm (1600 mg/m^3)

1985-86 Toxicity Data*
Mouse, oral, LD_{50}: 2250 mg/kg; no toxic effects noted
Mouse, inhalation, LC_{50}: 41,500 mg/m^3/2 hr; no toxic effects noted
Rabbit, oral, LD_{Lo}: 4000 mg/kg; toxic effects not yet reviewed

* See NIOSH, *RTECS* (GV6125000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 214 °F (101 °C)
Freezing Point: -196 °F (-126.3 °C)
Vapor Pressure: 43 mm Hg at 77 °F (25 °C)
Saturated Vapor Density (air = 1.2 kg/m^3): 1.362 kg/m^3 or 0.085 lb/ft^3
Viscosity: <32.6 SUS
Refraction index: 1.4231 at 20 °C/D

Molecular Weight: 98.2
Density: 0.7694 at 68 °F (20/4 °C)
Water Solubility: Insoluble, floats on water
Other Solubilities: Soluble in ethyl alcohol and ethyl ether; miscible in petroleum ether, acetone, benzene, and carbon tetrachloride
Odor Threshold: 500 ppm

Appearance and Odor: Colorless liquid with a faint, benzene-like odor. Methylcyclohexane's 500-ppm odor threshold is insufficient to prevent overexposure.

Section 4. Fire and Explosion Data

Flash Point: 25 °F (-4 °C), CC	Autoignition Temperature: 482 °F (250 °C)	LEL: 1.2% v/v	UEL: 6.7% v/v

Extinguishing Media: Methylcyclohexane is a Class 1B flammable liquid. For small fires, use dry chemical, carbon dioxide (CO_2), or regular foam. For large fires, use fog or regular foam. Water may be ineffective in fighting fire.

Unusual Fire or Explosion Hazards: Vapors may travel to an ignition source and flash back. Container may explode in heat of fire. Methylcyclohexane floats on water and poses a vapor explosion hazard indoors, outdoors, and in sewers.

Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Also, use fully protective clothing. Structural firefighters' protective clothing provides only *limited* protection. If possible without risk, remove container from fire area. Apply cooling water to sides of container until long after fire is extinguished. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if this is impossible, withdraw and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Methylcyclohexane is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Strong oxidizers

Conditions to Avoid: Exposure to heat and ignition sources and contact with strong oxidizers.

Hazardous Products of Decomposition: Thermal oxidative decomposition of methylcyclohexane can produce carbon dioxide (CO_2) and acrid smoke and fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(142) and OSHA(164) do not list methylcyclohexane as a carcinogen.

Summary of Risks: At high concentrations, methylcyclohexane produces narcosis in animals and is expected to do the same in humans. It is irritating to the eyes and respiratory tract. Most methylcyclohexane is absorbed via inhalation and small amounts are exhaled or excreted unchanged through urine. The majority enters the bloodstream where it is metabolized and excreted in urine as glucuronic or sulfuric acid conjugates.

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Section 6. Health Hazard Data, *continued*

Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, respiratory system.
Primary Entry Routes: Inhalation, skin and eye contact.
Acute Effects: Vapor inhalation can cause lightheadedness, drowsiness, nausea, vomiting, and possible unconsciousness (at very high concentrations). Methylcyclohexane is irritating and defatting to skin. Thickening and ulceration of skin occurred when applied to rabbit skin. Vascular and degenerative kidney lesions were observed in animal studies. The probable human oral lethal dose is 0.5 to 5 g/kg.
Chronic Effects: None reported.
FIRST AID
Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. Vomiting is not recommended since it may lead to aspiration of vomitus, especially because methylcyclohexane has <35 SUS.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Treatment is symptomatic and supportive.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. Cleanup personnel should protect against vapor inhalation and skin contact. If possible without risk, shut off leak. For small spills, take up with earth, sand, vermiculite or other absorbent, noncombustible material and place in suitable container. For large spill, dike far ahead of liquid spill for later disposal or reclamation. Water spray may reduce vapor but it may not prevent ignition in closed spaces. Follow applicable OSHA regulations (29 CFR 1910.120).
Ecotoxicity Values: Trout and flagfish concentrated methylcyclohexane 150-fold after a 7-day exposure to 0.83 to 1.85 mg/L.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.21): No. D001, Characteristic of ignitability
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4, "Unlisted Hazardous Waste, Characteristic of ignitability"): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] Use sufficient dilution ventilation to maintain airborne concentrations less than 25% of the LEL (Sec. 4).
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in cool, dry, well-ventilated area away from ignition sources and oxidizing agents. Contain storage rooms to prevent the spread of escaping liquid and use explosion-proof electrical installations.
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level.
Administrative Controls: Consider preplacement and periodic medical exams of exposed workers that emphasize the skin and respiratory system. Strict fire protection and prevention measures are required in all storage, handling, and shipping procedures.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Methylcyclohexane
DOT Hazard Class: Flammable liquid
ID No.: UN2296
DOT Label: Flammable liquid
DOT Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Methylcyclohexane
IMO Hazard Class: 3.2
ID No.: UN2296
IMO Label: Flammable Liquid
IMDG Packaging Group: II

MSDS Collection **References:** 73, 89, 100, 101, 103, 126, 127, 132, 133, 136, 139, 148, 149, 153, 159, 162, 163, 164, 167
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 825
Dinitrophenol

Issued: 6/92

Section 1. Material Identification

Dinitrophenol ($C_6H_3(NO_2)_2OH$) Description: Contains six isomers (2,3-; 2,4-; 2,5-; 2,6-; 3,4-; 3,5-) of which the 2,4- isomer is the most industrially important. Derived by the action of sodium hydroxide on 1-chloro-2,4-dinitrotoluene or by heating phenol with dilute sulfuric acid, cooling, and then nitrating while keeping the temperature at ~122 °F (50 °C). The product is purified through crystallization. Used as a dyestuff intermediate, wood preservative, insecticide, indicator, reagent for potassium and ammonium ions, photographic developer; in explosives and formerly (as recently as 1986) for weight loss.

Other Designations: (CAS No. 25550-58-7: dinitrophenol solution; DNP); (CAS No. 66-56-8: 2,3-dinitrophenol); (CAS No. 51-28-5: 2,4-dinitrophenol; Aldifen; Chemox PE; Fenoxyl Carbon N; 1,-hydroxy-2,-4-dinitrobenzene; Maroxol-50; Nitro Kleenup; Solfo Black B; Tertrosulphur Black PB; α–DNP); (CAS No. 329-71-5: 2,5- dinitrophenol; γ-DNP); (CAS No. 573-56-8: 2,6-dinitrophenol; ß-DNP); (CAS No. 577-71-9: 3,4-dinitrophenol); (CAS No. 586-11-8: 3,5-dinitrophenol).

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Dry	
R	3
I	3
S	3*
K	1

* Skin absorption

Wet	
R	3
I	3
S	3*
K	3

* Skin absorption

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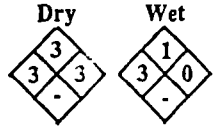

Dry HMIS	
H	3
F	3
R	3
PPG†	† Sec. 8

Wet HMIS	
H	3
F	1
R	0
PPG†	† Sec. 8

Cautions: Dinitrophenol highly toxic material that interferes with oxygen metabolism in the body through inhalation and skin and eye absorption. This material is highly explosive if allowed to become dry (<15 % water by weight).

Section 2. Ingredients and Occupational Exposure Limits

Dinitrophenol, ca 100% (commercial product is usually a mixture of 2,3-; 2,4-; and 2,6-isomers)

1991 OSHA PEL
8-hr TWA: 0.2 mg/m³)*

1991-92 ACGIH TLV
None established

1990 NIOSH REL
None established

1990 DFG (Germany) MAK
None established

1985-86 Toxicity Data†
Human, oral, LD_{Lo}: 4300 µg/kg; toxic effects not yet reviewed
Rat, oral, TD_{Lo}: 2040 mg/kg administered from 8 day prior to mating to 21 day post-pregnancy produced stillbirth
Rat, oral, LD_{50}: 30 mg/kg; no toxic effect noted
Rabbit, skin: 300 mg applied intermittently for 4 weeks produced mild irritation

* Guideline based on data for dinitro-*o*-cresol.
† See NIOSH, *RTECS* (SL2800000) 2,4-isomer, for additional irritation, mutation, reproductive, and toxicity data. Future data may be provided for the other isomers; (SL2700000) 2,3-; (SL2900000) 2,5-; (SL2975000) 2,6-; (SL3000000) 3,4-; (SL3050000) 3,5-; and (SL2625000) dinitrophenol solution.

Section 3. Physical Data

Boiling Point: Sublimes when carefully heated
Melting Point: 291.2 °F (144 °C)*, 233.6 °F (112 °C)†, 145.4 °F (63 °C)‡
Vapor Pressure: 10 to 5 *(or less)* mm Hg at 68 °F (20 °C)
Saturated Vapor Density (air = 1.2 kg/m³ or 0.075 lbs/ft³): 1.243 to 1.283 kg/m³ or 0.078 to 0.080 lbs/ft³

Molecular Weight: 184.1
Specific Gravity: 1.68 at 68 °F (20 °C)
Water Solubility: Slightly soluble in cold, freely in hot
Other Solubilities: Soluble in acetone, benzene, carbon tetrachlor chloroform, ethyl alcohol, ethyl ether, and pyridine

Appearance and Odor: Yellow crystals or in solution; colorless liquid below pH 4 and yellow liquid above pH 4

* (2,3-isomer), † (2,4-isomer), ‡ (2,6-isomer)

Section 4. Fire and Explosion Data

Flash Point: Varies, depending on isomer	Autoignition Temperature: None reported	LEL: None reported	UEL: None reported

Extinguishing Media: Flood fires with water. If water is unavailable, use dry chemical or dirt. **Unusual Fire or Explosion Hazards:** Dinitrophenol is highly explosive if it becomes dry and is exposed to heat, flame, or shock. **Special Fire-fighting Procedures:** Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Also, wear fully protective clothing. Do not move cargo or vehicle if cargo has been exposed to heat. For massive fire in cargo area use monitor nozzles or unmanned hose holders; if this is impossible, withdraw from area and let fire burn. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Dinitrophenol is stable at room temperature in closed containers under normal storage and handling conditions and with at least 15% water by weight. It becomes explosive when dry and subjected to shock, heat, or flame. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Dinitrophenol is volatile with steam and incompatible with strong oxidizers. The 2,4-isomer forms explosive salts with alkalies and ammonia. **Conditions to Avoid:** Exposure to heat, flame, incompatibles, or shock and allowing dinitrophenol to become dry. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of dinitrophenol can produce carbon dioxide (CO_2) and toxic nitrogen oxides (NO_x).

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[142] and OSHA[164] do not list dinitrophenol as a carcinogen.
Summary of Risks: Dinitrophenol is an acute poison which disrupts cellular metabolism in all tissues by disturbing the essential process of oxidative phosphorylation resulting in high fever, and elevated blood pressure, pulse, and respiration rate. If heat production is greater than heat loss, fatal hyperthermia may result. If not fatal, effects are rapidly and completely reversible usually within 12 to 24 hr. Effects are most severe in hot workplaces. Chronic or cumulative effects from small doses over long time periods do not occur. Dinitrophenols half-life in the human body is 5 to 14 days (readily reduced to aminophenol which is less toxic and excreted in the urine) and the fatal human dose is 1 to 3 grams by mouth, at once or even over a few days. **Medical Conditions Aggravated by Long-Term Exposure:** Possibly, thyroid, liver, cardiovascular, and kidney diseases. **Target Organs:** Skin, respiratory, cardiovascular, and central nervous (CNS) systems, liver, and kidney. **Primary Entry Routes:** Inhalation and skin contact/absorption. **Acute Effects:** Inhalation can cause headache, coughing, profuse sweating, thirst, intense fatigue, high fever, rapid pulse, warm and flushed skin, rapid, difficult breathing, anxiety and confusion, convulsions, loss of consciousness, risk of pulmonary edema (fluid in lungs) and possible death due to circulatory or respiratory collapse. Skin contact produces rapid yellow staining, irritation, redness,

Continue on next page

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Section 6. Health Hazard Data, *continued*

swelling, blisters, and delayed symptoms identical to those from inhalation due to absorption through the skin. Eye contact produces burning pain, watering, and inflammation of lids. If ingestion occurs, symptoms include burning of the mouth and throat, salivation, dizziness, nausea and vomiting, bright yellow stools, and symptoms associated with inhalation. If death occurs, it is sudden and rigor mortis (rigidity of the muscles after death) quickly ensues. Liver and kidney damage may develop 12 to 72 hr after exposure. **Chronic Effects:** Hypersensitivity may result from repeated exposures.

FIRST AID *If victim is feverish, bathe head and hands in tepid water or wrap legs in soaked towels. Consider hypothermic bath or blanket if tepid water is insufficient. Do not give aspirin or other salicylates.*

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly closed. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Yellow discoloration does not need to be totally removed to prevent absorption. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. After vomiting give 2 tablespoons activated charcoal in 8 oz. water to drink.

Note to Physicians: Monitor fluids and electrolytes, control hyperthermia, and test for dinitrophenol or its metabolite, *aminophenol*, in the urine using Derrian's Test. Due to the relatively slow excretion of DNP (5 to 14-day half-life), it is recommended that persons showing toxicity symptoms not be exposed to any amount of dinitophenol for at least 6 weeks.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against inhalation and skin contact. For small spills, flush area with flooding amounts of water. For large spills, wet down with water (*do not* let dinitrophenol dry out as it becomes explosive) and dike for later disposal. If spilled in water, trap at bottom and lift with mechanical dredges. If dissolved, apply activated carbon at 10 times the spilled amount and remove with suction hoses. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Degradation:** Dinitrophenols inhibit microbial growth of natural aquatic systems because they interfere with the metabolic process of oxidative phosphorylation. In water, it may undergo direct photolysis due to absorption of UV light wavelengths >290 nm or react with alkylperoxy radicals. It is not expected to absorb to suspended solids although it may to some clay minerals. In air, dinitrophenol is expected to exist in particulate and vapor form. It may photolyze, be physically removed by settling or washout in precipitation, or may react with photochemically generated hydroxyl radicals. Its estimated vapor phase half-life is 14 hr. **Soil Absorption/Mobility:** Dinitrophenol is highly mobile but may absorb to some clay minerals. It is highly resistant to aerobic biodegradation. **Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed (2,4-isomer) as a RCRA Hazardous Waste (40 CFR 261.33): No. P048
Listed as a CERCLA Hazardous Substance*† (40 CFR 302.4), Final Reportable Quantity (RQ): 10 lb (4.54 kg) [* per RCRA, Sec. 3001‡§, CWA, Sec. 307(a)§, and CWA Sec. 311 (b)(4)§]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed (2,4-isomer) as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

† the 2,5- and 2,6- isomers are listed but RCRA, CWA, or CAA are not designated.
‡ Dinitrophenol solution
§ 2,4-isomer

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Do not wear leather because it absorbs dinitrophenol; discard contaminated leather immediately. **Ventilation:** Provide general and local exhaust dilution ventilation systems to maintain airborne concentrations as low as possible. Consider using the OSHA PEL for dinitro-*o*-cresol of 0.2 mg/m^3 as a guideline. Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Contaminated clothing is easily recognized by a bright yellow stain. Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, well-ventilated area away from heat and ignition sources and incompatibles (Sec. 5). **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. During manufacture, minimize dust by installing exhaust ventilation (with appropriate dust collection) at points where containers are filled or centrifuges are emptied. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize liver and kidney function. Monitor nitrophenol urine levels regularly. Educate workers about the dinitrophenols toxic properties.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Dinitrophenol solution
DOT Hazard Class: Poison B
ID No.: UN1599
DOT Label: Poison
DOT Packaging Exceptions: 173.345
DOT Packaging Requirements: 173.362a

IMO Shipping Name: Dinitrophenol, *dry or wetted with < 15% water by weight*; Dinitrophenol, solution *in water or flammable liquid*; Dinitrophenol, wetted *with by weight at least 15% water*
IMO Hazard Class: 1.1 D; 6.1; 4.1
ID No.: UN0076; UN1599; UN1320
IMO Label: Explosive (1.1D), Poison; Poison, Flammable Liquid (only if Flashpoint is 23 to 61 °C); Flammable solid, Poison
IMDG Packaging Group: --; II; I

MSDS Collection **References:** 26, 73, 100, 103, 124, 126, 127, 132, 133, 136, 139, 140, 153
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 830
1,1-Dichloroethane

Issued: 6/92

Section 1. Material Identification

1,1-Dichloroethane (CH_3CHCl_2) Description: Derived by various methods; by direct chlorination of ethane, as a side product of chloral manufacture, by treating ethylene and chlorine with calcium chloride, by action of phosphorus chloride on acetaldehyde, and the reaction of hydrogen chloride and vinyl chloride at 20 to 55 °C in the presence of an aluminum, ferric, or zinc chloride catalyst. Found as an air contaminant in submarines and space craft. Its largest industrial use is in the production of 1,1,1-trichloroethane. Also used as a cleansing agent, degreaser, solvent for plastics, oils, and fats, grain fumigant, chemical intermediate; in insecticide sprays, rubber cementing, fabric spreading, paint and varnish removers, in ore flotation, vinyl chloride production, and as a coupling agent in anti-knock gasoline. Formerly used as an anesthetic.

R 1
I 3
S 2
K 4

NFPA

HMIS
H 2
F 3
R 0
PPG*
* Sec. 8

Other Designations: CAS No. 75-34-3; assymetrical dichloroethane; chlorinated hydrochloric ether; ethylidene chloride; ethylidene dichloride.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: 1,1-Dichloroethane is volatile and highly flammable. It is irritating to the eyes and respiratory tract and inhalation of high concentrations causes an anesthetic effect.

Section 2. Ingredients and Occupational Exposure Limits

1,1-Dichloroethane, reagent grade (99.7%). Impurities consist of ethyl chloride (0.02%), trichloroethylene (0.08%), butylene oxide (0.08%), ethylene dichloride (0.01%), and unknown (0.14%).

1991 OSHA PEL
8-hr TWA: 100 ppm (400 mg/m³)

1990 IDLH Level
4000 ppm

1990 NIOSH REL
8-hr TWA: 100 ppm (400 mg/m³)

1991-92 ACGIH TLVs*
TWA: 200 ppm (810 mg/m³)
STEL: 250 ppm (1010 mg/m³)

1990 DFG (Germany) MAK
100 ppm (400 mg/m³)
Half-life: < 2hr
Peak Exposure Limit: 200 ppm/30 min. average value/maximum of 4 peaks per shift

1985-86 Toxicity Data†
Mouse, oral, TD_{Lo}: 185 g/kg administered intermittently for 78 wk produced uterine tumors.
Rat, oral, LD_{50}: 725 mg/kg; toxic effects not yet reviewed.‡
Rat, inhalation, TC_{Lo}: 6000 ppm/7 hr administered during 6 to 15 days of pregnancy caused developmental abnormalities of the musculoskeletal system.

* Notice of intended change to 100 ppm/405 mg/m³.
†See NIOSH, *RTECS* (KI0175000), for additional reproductive, tumorigenic and toxicity data.
‡ Considered a possible error since subsequent studies at higher concentrations failed to produce comparative results.(133)

Section 3. Physical Data

Boiling Point: 135 °F (57.3 °C)
Melting Point: -143 °F (-96.98 °C)
Vapor Pressure: 230 mm Hg at 77 °F (25 °C)
Saturated Vapor Density (air = 1.2 kg/m³ or 0.075 lbs/ft³): 2.076 kg/m³ or 0.129 lbs/ft³
Refraction Index: 1.4166 at 68 °F (20 °C)
Surface Tension: 24.75 dyne/cm at 68 °F (20 °C)

Molecular Weight: 98.97
Specific Gravity: 1.174 at 68 °F (20/4 °C)
Water Solubility: Slightly, 0.5%
Other Solubilities: Very soluble in alcohol and ether, soluble in acetone, benzene, and fixed and volatile oils.
Relative Evaporation Rate (BuAc=1): 11.6
Odor Threshold: 49 to 1359 ppm; odor is not sufficient to warn against overexposure

Appearance and Odor: Colorless, mobile, oily liquid with a chloroform odor and a saccharin taste.

Section 4. Fire and Explosion Data

Flash Point: 17 °F (-8.33 °C) CC*	Autoignition Temperature: 856 °F (493 °C)	LEL: 5.6% v/v	UEL: 11.4% v/v

Extinguishing Media: A Class 1B Flammable Liquid. For small fires, use dry chemical, carbon dioxide (CO_2), or "alcohol-resistant" foam. For large fires, use fog or "alcohol-resistant" foam. Water may be ineffective unless used as a "blanket".
Unusual Fire or Explosion Hazards: Vapors may travel to an ignition source and flash back. Container may explode in heat of fire.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing will provide only limited protection. If possible without risk, move container from fire area. Apply cooling water to sides of containers until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if this is impossible, withdraw from area and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers (explosion) or waterways.

* 22 °F (-5.5 °C), OC(148)

Section 5. Reactivity Data

Stability/Polymerization: 1,1-Dichloroethane is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Incompatible with strong oxidizers and forms acetaldehyde in contact with caustics. 1,1-Dichloroethane will attack some forms of plastics, rubber, and coatings.
Conditions to Avoid: Exposure to heat and ignition sources and contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of 1,1-dichloroethane can produce carbon dioxide (CO_2), irritating hydrogen chloride (HCl) and toxic phosgene ($COCl_2$) fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list 1,1-dichloroethane as a carcinogen. However, the National Cancer Institute has recommended caution due to analogy to other chloroethanes such as 1,2-dichlorothane which are shown to cause cancer in animals.
Summary of Risks: 1,1-Dichloroethane is irritating to the eyes and respiratory system. It causes varying degrees of central nervous system (CNS) disturbance depending on the concentration and duration of exposure. Liver and kidney toxicity is controversial.

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Section 6. Health Hazard Data, *continued*

Some sources report that severe, acute exposures can cause damage, some quote recent detailed chronic studies which indicate little capacity for damage; still others refute the possibility of acute damage even from very high exposures. In reviewing the data it appears likely that chronic exposure will not cause kidney or liver damage but acute exposures to high concentrations may. There is definite evidence that 1,1-dichloroethane produces liver damage in monkeys, dogs, and rats when exposed to 98 ppm/90 days. It is also unclear whether or not 1,1-dichloroethane is absorbed through the skin. There are reports of absorption (although not in toxic amounts) and others claiming there is no absorption. Given this controversial data it is best to take precautions as if skin absorption, and liver and kidney damage were proven to occur. **Medical Conditions Aggravated by Long-term Exposure:** Chronic respiratory and skin disease, neurological damage, and liver or kidney disorders. **Target Organs:** Skin, CNS, liver, kidney. **Primary Entry Routes:** Inhalation and skin contact. **Acute Effects:** Inhalation symptoms include eye, nose, and throat irritation, headache, dizziness, coughing, staggering, disturbed vision, irregular heartbeat (can result in sudden death), unconsciousness, narcosis, coma, and death due to cardiac or respiratory failure. There is the risk of pulmonary edema (fluid in lungs). Skin contact is irritating and causes defatting, redness and swelling. Vapor contact with the eyes causes irritation, watering eyes and lid inflammation. Splashes to the eyes produces a burning sensation, watering, and lid inflammation. **Chronic Effects:** Repeated skin contact can cause a rash and scaliness. Repeated inhalation may have neurological effects.

FIRST AID *Emergency personnel should protect against contamination.*

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Do *not* allow victim to rub or keep eyes tightly shut. Immediately consult an ophthamlologist. **Skin:** 1,1-Dichloroethane vaporizes easily and poses an inhalation hazard as well. *Quickly and carefully* remove contaminated clothing; *1,1-dichloroethane is flammable!* Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. After vomiting, give 2 tbsp activated charcoal in 8 oz water to drink.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Proper ventilation is the main treatment for acute exposure. Be prepared to support respiration if needed. Monitor liver function studies, urine analysis, and creatinine with acute and chronic exposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against inhalation and skin contact. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and using nonsparking tools, place in a suitable container. For large spills, dike far ahead of liquid spill for disposal or reclamation. Do not allow 1,1-dichloroethane to enter confined areas such as a sewer because of potential explosion. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Degradation:** In soil, 1,1-dichloroethane volatilizes rapidly but may leach into groundwater. In water it will volatilize from a pond, lake, or river with a half-life of 6 to 9 days, 5 to 8 days, and 24 to 32 hr, respectively. In the atmosphere it will degrade by reaction with photochemically produced hydroxyl radicals with a 62 day half-life. It may also be carried back to soil via rain.

Ecotoxicity Values: *Artemia salina*, brine shrimp, TLm 320 mg/L/24 hr; *Lagodon rhomboides*, pinperch, TLm 160 mg/L/24 hr; *Poecilia reticulata*, guppies, LC_{50} 202 ppm/7 days.

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

EPA Designations

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

SARA Toxic Chemical (40 CFR 372.65): Not listed

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U076

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg)

[* per RCRA, Sec. 3001 & CWA, Sec. 307(a)]

OSHA Designations Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH/MSHA-approved respirator. For < 1000 ppm, use any supplied-air respirator or SCBA. For < 2500 ppm, use any supplied-air respirator operated in a continuous flow mode. For < 4000 ppm, use any supplied-air respirator or SCBA with a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent repeated or prolonged skin contact. Polyvinyl alcohol is recommended as suitable material for PPG. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Thoroughly decontaminate personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from ignition sources and incompatibles (Sec. 5). Label containers to indicate the contents' high flammability. Periodically inspect containers for cracks and leaks. To prevent static sparks, electrically ground and bond all equipment used in 1,1-dichloroethane manufacture, use, storage, transfer, and shipping.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level.

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers emphasizing the skin, CNS, liver, and kidney. Educate workers about the hazards of 1,1-dichloroethane and the necessary precautions to reduce or prevent exposure.

Transportation Data (49 CFR 172.102)

IMO Shipping Name: 1,1-Dichloroethane
IMO Hazard Class: 3.2
ID No.: UN2362
IMO Label: Flammable Liquid
IMDG Packaging Group: II

MSDS Collection **References:** 73, 89, 101, 103, 126, 127, 131, 132, 133, 136, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168, 171

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD

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Material Safety Data Sheets Collection:
Sheet No. 337
n-Butyl Alcohol
Issued: 10/78 Revision: D, 1/93

Section 1. Material Identification

40

R 1
I 2
S 2*
K 3
*Skin absorption

NFPA
3
1 0
–

HMIS
H 1
F 3
R 0
PPE†
† Sec. 8

***n*-Butyl Alcohol ($C_2H_5CH_2CH_2OH$) Description:** Naturally occurring in Brazilian peppermint oil. Derived by several processes including reduction of butyraldehyde with sodium borohydride, from ethylene oxide and triethylaluminum, oxidation of tributyl borane, carbohydrate fermentation, condensation of acetaldehyde to crotonaldehyde with subsequent hydrogenation, or by passing ethyl alcohol over magnesium oxide/copper oxide at 617 °F (325 °C) and 128 atm. Used as a solvent for fats, oils, waxes, resins, shellac, varnish, gums, vegetable oils, alkaloids, and dyes; in manufacture of lacquers, rayon, detergents, other butyl compounds, and pharmaceuticals (extractant for antibiotics, vitamins, and hormones); in microscopy preparing paraffin imbedding materials; as a dehydrating agent; in medicine for control of post-operative otolaryngeal pain and for an anti-hemorrhagic effect in advanced cancer patients; in veterinary medicine as a bactericide.
Other Designations: CAS No. 71-36-3, *n*-butanol, 1-butanol, butyl hydroxide, butyric alcohol, CCS 203, Henostyp, 1-hydroxybutane, methylolpropane, propylcarbinol, propyl methanol.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.
Cautions: *n*-Butyl alcohol is irritating to the eyes and skin and can cause dermatitis. Central nervous system depression may occur at high concentrations. It is a highly flammable liquid.

Section 2. Ingredients and Occupational Exposure Limits

n-Butyl alcohol, ca 99.9%. May contain 0.1% water by wt.

1992 OSHA PEL
Transitional Limit:
TWA, 100 ppm (300 mg/m^3)
Final Rule Limit:
Ceiling, 50 ppm (150 mg/m^3), *skin*

1990 IDLH Level
8000 ppm

1990 NIOSH REL
Ceiling: 50 ppm (150 mg/m^3), *skin*

1992-93 ACGIH TLV
Ceiling: 50 ppm (152 mg/m^3), *skin*

1990 DFG (Germany) MAK
TWA: 100 ppm (300 mg/m^3)
Category II: substances with systemic effects
Half-life: < 2 hr
Peak Exposure Limit: 200 ppm, 30 min average value, 4/shift

1992 Toxicity Data*
Human, eye, 50 ppm caused irritation.
Human, inhalation, TC_{Lo}: 25 ppm caused conjunctival and respiratory irritation.
Rat, oral, LD_{50}: 790 mg/kg; toxic effects not yet reviewed
Rabbit, skin, LD_{50}: 3400 mg/kg; no toxic effect noted

* See NIOSH, *RTECS* (EO1400000), for additional irritation, mutation, and toxicity data.

Section 3. Physical Data

Boiling Point: 243 °F (117 °C)
Freezing Point: -130 °F (-90 °C)
Vapor Pressure: 6.5 mm Hg at 77 °F (25 °C)
Ionization Potential: 10.04 eV
Relative Evaporation Rate (BuAc = 1): 0.46
Refraction Index: 1.3993 at 68 °F (20 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3): 1.216 kg/m^3
Liquid Surface Tension: 69.3 dyne/cm

Molecular Weight: 74.12
Specific Gravity: 0.8109 at 68 °F (20 °C)
Water Solubility: Soluble, 9.1 mL/100 mL water
Other Solubilities: Soluble (10%) in acetone, benzene, ethanol, and ether.
log Octanol Water Partition Coefficient: 0.88
Viscosity: 36.1 cP at -50.6 ° F (-50.9 °C), 5.18 cP at 32 °F (0 °C), 2.94 cP at 68 °F (20 °C), 0.54 cP at 212 °F (100 °C).
Critical Temperature and Pressure: 289.8 °C and 43.6 atm

Appearance and Odor: Colorless liquid with a harsh fuel oil and banana smell. The odor threshold is 0.12 to 11 ppm.

Section 4. Fire and Explosion Data

Flash Point: 84 °F (28.9 °C) CC, 98 °F (37 °C) OC	**Autoignition Temperature:** 650 °F (343 °C)	**LEL:** 1.4% v/v	**UEL:** 11.2% v/v

Extinguishing Media: A Class I C Flammable Liquid. For small fires, use dry chemical, carbon dioxide, water spray, or 'alcohol-resistant' foam. For large fires, use water spray, fog, or 'alcohol-resistant' foam. **Unusual Fire or Explosion Hazards:** Burning Rate = 3.2 mm/min. Vapors may travel to an ignition source and flash back. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Cool container sides with water until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice tank discoloration due to fire because a BLEVE may be imminent. Do not release runoff from fire control methods to sewers or waterways; dike for proper disposal.

Section 5. Reactivity Data

Stability/Polymerization: *n*-Butyl alcohol is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include aluminum, chromium trioxide, organic peroxides, and strong oxidizers. Attacks some forms of plastic, rubber, coatings. **Conditions to Avoid:** Exposure to heat, ignition sources, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of *n*-butyl alcohol can produce carbon monoxide and acrid smoke.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(183) NTP,(169) and OSHA(183) do not list *n*-butyl alcohol as a carcinogen. **Summary of Risks:** *n*-Butyl alcohol is potentially more toxic (seen in animal studies) than its lower homologues but its airborne hazards are substantially reduced due to a low vapor pressure. The estimated human lethal oral dose is 3 to 7 ounces. Vapor inhalation is irritating to the eyes and respiratory tract. Skin contact is irritating and may lead to dermatitis. *n*-Butyl alcohol can be absorbed through the skin; direct hand contact for 1 hr resulted in a body burden 4x that from inhalation of 50 ppm/1 hr. The average odor threshold is ~ 15 ppm but because of rapid olfactory fatigue it rises to 10,000 ppm after adaptation.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Two studies suggest unprotected noise exposure concurrent with exposure to butyl alcohol (~ 80 ppm) increased hearing loss beyond that occurring from noise exposure alone. Animal studies show lowered white blood cell counts, lymphocytosis, lung hemorrhage, albuminuria (albumin in urine), early degenerative liver changes, and cortical/tubular degeneration of the kidneys. **Medical Conditions Aggravated by Long-Term Exposure:** Dermatitis. **Target Organs:** Eyes, ears, skin, respiratory tract. **Primary Entry Routes:** Inhalation, eye contact, skin contact/absorption. **Acute Effects:** Skin contact produces drying and cracking due to its defatting action. Vapor inhalation is irritating to respiratory tract and eyes. Conjuctival edema (swelling), headache, dizziness, and drowsiness may also occur. **Chronic Effects:** Repeated exposure to 50 to 200 ppm leads to blurred vision, burning, and sensitivity to light. Symptoms become more severe toward week's end and decrease over the weekend. Hearing loss and vestibular damage resulting in vertigo may occur from current exposure to *n*-butyl alcohol and noise pollution.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water. If pain, photophobia, or lacrimation persists after 15 min. of flushing, consult an ophthalmologist. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting. **Note to Physicians:** Treatment is symptomatic and supportive.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. Dike far ahead of large spill for later disposal or reclamation. Prevent entry into sewers, drains, and waterways. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** *Pseudomas putida* (bacteria), 650 mg/L inhibited cell multiplication; fathead minnow, LC_{50} = 1940 mg/L/1 hr; aquatic plant toxicity = 8500 ppm. **Environmental Degradation:** In air, *n*-butyl alcohol will react with photochemically produced hydroxyl radicals with an estimated half-life of 2.3 days. In a sunlit urban atmosphere the half-life is reduced to 5 hr. In water, some butyl alcohol will biodegrade and the rest will volatilize with estimated half-lives of 2.4 hr, 3.9 hr, and 125.9 days in streams, rivers, and lakes, respectively. The ability to volatilize depends on temperature, turbulence, wind speed, current velocity, and water depth. If released to soil, *n*-butyl alcohol may volatilize, biodegrade, or leach into groundwater. **Soil Absorption/Mobility:** A soil absorption coefficient (Koc) of 71.6 indicates moderate to high mobility. **Disposal:** A good candidate *for* liquid injection incineration, with a temperature range of 650 to 1600 °C and a residence time of 0.1 to 2 sec; *for* rotary kiln incineration at 820 to 1600 °C for a few seconds, and *for* fluidized bed incineration at 450 to 980 °C for a few seconds. Land disposal is limited because sub-surface dilution does not adequately keep groundwater concentrations below regulated levels. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): U031
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910 1000, Table Z-1-A)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 5000 lb (2270 kg) [* per RCRA, Sec. 3001]

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use any powdered air purifying respirator with organic vapor cartridges. For < 1250 ppm, use any supplied-air respirator (SAR) operated in continuous-flow mode. For < 2500 ppm, use any air-purifying, full face respirator (gas mask) with a chin style, front or back mounted organic vapor canister, or any SAR or SCBA with a full facepiece. For < 8000 ppm, use any SAR with a full facepiece and operated in pressure-demand or positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Teflon and chlorosulphonated ethylene rubber with a breakthrough time (BT) of > 8 hr; and butyl rubber, polyethylene, neoprene, and nitrile rubber with a BT of > 4 hr are suitable materials for protective gear. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage/Handling Requirements: Prevent physical damage to containers. Store in a cool, dry, dark, well-ventilated area away from heat, ignition sources, and incompatibles. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Use electrical equipment of Class I, Group D. Use non-sparking tools during maintenance operations and electrically ground and bond equipment. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on the eyes, skin and respiratory tract.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Butanols
DOT Hazard Class: 3
ID No.: UN1120
DOT Packing Group: III
DOT Label: Flammable Liquid
Special Provisions (172.102): B1, T1

Packaging Authorizations
a) Exceptions: 173.150
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger Aircraft or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: —

MSDS Collection **References:** 23, 54, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 148, 153, 159, 167, 168, 169, 171, 176, 183
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MD

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Material Safety Data Sheets Collection:

Sheet No. 350
Carbon Disulfide

Issued 11/77 Revision: D, 3/92

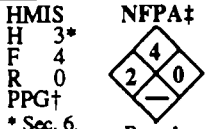
Section 1. Material Identification

Carbon Disulfide (CS_2) Description: Prepared industrially by heating charcoal with vaporized sulfur or by reaction of natural petroleum fractions with sulfur. Used in manufacturing soil disinfectants, electronic vacuum tubes, viscose rayon, cellophane, flotation agents, ammonium salts and carbon tetrachloride; in insecticides, chemical analysis, electroplating, fumigation, oil extraction, dry cleaning and degreasing; and as a solvent for lipids, sulfur, rubber, oils, resin and waxes.
Other Designations: CAS No. 75-15-0, carbon bisulfide, dithiocarbonic anhydride, sulphocarbonic anhydride, Weeviltox.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.
Cautions: Carbon disulfide is a highly flammable, dangerous explosion hazard. It is irritating to eyes, skin, and mucous membranes, and toxic to the central nervous (CNS), peripheral nervous (PNS), and cardiovascular (CVS) systems.

‡ The NFPA health rating of "2" is misleading due to the severity of this material's toxicity to the CNS, CVS, and PNS and its chronic effects. A "3" is more appropriate.

HMIS
H 3*
F 4
R 0
PPG†
* Sec. 6, Chronic Effects
† Sec. 8

NFPA‡



R 1
I 4
S 3§
K 4
§Skin absorption

Section 2. Ingredients and Occupational Exposure Limits

Carbon disulfide, ca 99% (major impurities are sulfur compounds)

1990 OSHA PELs (Skin)
8-hr TWA: 4 ppm (12 mg/m³)
15-min STEL: 12 ppm (36 mg/m³)

1990 NIOSH RELs
TWA: 1 ppm (10 mg/m³)
STEL: 10 ppm (30 mg/m³)

1990 IDLH Level
500 ppm

1991-92 ACGIH TLV (Skin)
TWA: 10 ppm (31 mg/m³)

1990 DFG (Germany) MAKs
TWA: 10 ppm (30 mg/m³)
Peak Exposure Limit: 20 ppm/30 min /4 x/shift, momentary value
Half-life: <2 hr

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 40 mg/m³/91 weeks produced paternal effects (spermatogenesis)
Human, inhalation, LC_{Lo}: 2000 ppm/5 min; no toxic effects noted
Human, oral, LD_{Lo}: 14 mg/kg; toxic effects not yet reviewed
Rat, oral, LD_{50}: 3188 mg/kg

* See NIOSH, *RTECS* (FF6650000), for additional mutation, reproductive and toxicity data.

Section 3. Physical Data

Boiling Point: 115 °F (46.5 °C)
Freezing Point: -168 °F (-110.8 °C)
Vapor Pressure: 300 mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 2.64
Coefficient of Viscosity: 0.363 at 68 °F (20 °C)
Molecular Weight: 76.13
Specific Gravity: 1.2632 at 68 °F (20 °C)
Water Solubility: Slightly, 220 mg/100 cc water at 71.6 °F (22 °C)
Other Solubilities: Soluble in alcohol, benzene and ether
Refraction Index: 1.66232 at 77 °F (25 °C)

Appearance and Odor: Clear, colorless to slightly yellow liquid with a sweet, chloroform-like odor when pure and a foul, rotten egg smell as the commercial product. The odor threshold is 0.1 to 0.2 ppm.
Comments: From both health effect and fire/explosion perspectives, this liquid's very high vapor pressure at room temperature indicates that airborne concentrations can build quickly to dangerous levels. Take precautions to ensure safety (Sec. 8).

Section 4. Fire and Explosion Data

Flash Point: -22 °F (-30 °C), CC	Autoignition Temperature: 194 °F (90 °C)	LEL: 1.5% v/v	UEL: 50% v/v

Extinguishing Media: Foams are more effective in carbon disulfide fires than previously believed, when water and dry chemical were the preferred extinguishing agents. Four foams tested are listed in order of increasing effectiveness: high-expansion, aqueous film-forming, fluoroprotein, and protein. If foam is unavailable, rely on carbon dioxide (CO_2) or water spray. Do not scatter material with more water than necessary to put out fire.
Unusual Fire or Explosion Hazards: Carbon disulfide's burning rate is 2.7 mm/min. Vapor may travel to an ignition source and flash back. Container may explode in heat of fire. CS_2 poses a vapor explosion hazard indoors, outdoors, and in sewers. Carbon disulfide can be ignited by friction, rusted or hot steam pipes, and may accumulate static electricity. Heat from an ordinary light bulb is enough to cause ignition.
Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is ineffective for fires involving carbon disulfide. Apply cooling water to sides of tanks until long after fire is extinguished. Stay away from ends of tanks. Immediately withdraw from area if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Carbon disulfide is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Carbon disulfide will decompose to its elements in contact with mercury fulminate. It is incompatible with alkali metals, chlorine and other halogens, nitrogen oxide, metal azides, oxidants, aluminum, ethylene diamine and zinc. Carbon disulfide reacts exothermically with phenyl copper-triphenylphosphine complexes.
Conditions to Avoid: Exposure to ignition sources and contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of carbon disulfide can produce carbon monoxide (CO), carbon dioxide (CO_2), and toxic sulfur oxides (SO_x)

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[142] and OSHA[164] do not list carbon disulfide as a carcinogen. **Summary of Risks:** CS_2 enters the body primarily via the lungs (inhalation) but can be absorbed via skin. It is irritating to skin, eyes, and mucous membranes and can cause serious damage to CVS, CNS, and PNS. CS_2 is cardiotoxic (toxic to heart), thrombotoxic (adversely affecting blood-clotting ability), and arrythmagenic (causing irregular heartbeat). A Parkinsonian-like effect is sometimesobserved. Exposure to 60 to 100 ppm for a short time can result in severe intoxication and death. Exposure to 5000 ppm is rapidly fatal. 70 to 90% of CS_2 is metabolized, with lungs and kidney excreting the rest. **Medical Conditions Aggravated by Long-Term Exposure:** Coronary heart disease and CNS disorders. **Target Organs:** Skin, CNS, PNS, CVS, eyes, liver, kidney.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Primary Entry Routes: Inhalation and skin contact/absorption. **Acute Effects:** CS_2 is irritating and corrosive to the eyes, skin, and mucous membranes. Introduction into eyes causes burning pain, red and swelling lids, and conjunctivitis. Skin contact with liquid may lead to burning and second- or third-degree burns. CS_2 defats tissue and skin sensitization may occur. Skin absorption can result in peripheral nerve damage. Other symptoms from inhalation or skin absorption include headache, dizziness, euphoria, convulsions, nausea, vomiting, muscle weakness, and in severe cases may lead to death by respiratory failure. **Chronic Effects:** Chronic exposure to carbon disulfide may increase the risk of arteriosclerosis as well as cause delirium, psychosis, bad dreams leading to insomnia, CNS damage, peripheral neuropathies (abnormal and usually degenerative state of the nerves causing pain and unstimulated sensations), appetite loss, tremors, gastric disturbances, liver dysfunction, optical neuritis, and retinal hemorrhages. In women, chronic exposure to carbon disulfide can cause menstrual disorders. Spontaneous abortions and premature births are reported.

FIRST AID

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting with 1 to 2 tablespoons of Ipecac (adult dose). After patient vomits, give 2 tablespoons activated charcoal in 8 oz. of water to drink.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Since effects may be delayed, keep victim under observation. The iodine-azide test is useful in detecting degree of exposure and hypersusceptibility of exposed workers. I.V. urea 0.5 to 1.5 g/kg is recommended to inactivate free carbon disulfide in the blood. Vitamin B6 in large doses is recommended. Obtain CBC, EKG, urinalysis, and electrolyte balance.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Plan and design appropriate emergency-response procedures prior to carbon disulfide spills or leaks.* Immediately notify safety personnel, isolate area, deny entry and stay upwind. Shut off all ignition sources. Cleanup personnel should wear fully encapsulating, vapor-protective clothing to protect against contamination. If possible, detoxify material before cleanup. For small spills, take up with earth, sand, vermiculite or other absorbent, noncombustible material and place in clean, dry containers with a secure lid for later disposal. For large spills, flush liquid to a special retention basin where it can collect under a layer of water (to prevent ignition or explosion) for disposal or reclamation. Perform all cleanup operations with nonsparking tools. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to water, carbon disulfide should volatilize with a half-life of 2.6 hr (according to model river plan) and should not bioconcentrate significantly in aquatic organisms. In the atmosphere, CS_2 reacts with atomic oxygen and photochemically produced hydroxyl radicals with a half-life of 9 days. **Environmental Toxicity Values:** Sunfish, LC_{100}, 100 µg/L/hr; trout, LC_{100}, 500 µg/L/0.1 hr. **Soil Absorption/Mobility:** Carbon disulfide is highly mobile and volatilizes or leaches into soil. **Disposal:** Large amounts of CS_2 may be distilled for reclamation and packaged for reuse. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. P022
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001 and CWA 311(b)(4)]
Listed as a SARA Extremely Hazardous Substance (40 CFR 355)
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For 10 ppm, use any chemical cartridge respirator with organic vapor cartridges. For 50 ppm, air-purifying respirator with organic vapor cartridges and a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. Suggested materials for protective clothing include polyvinyl alcohol (PVA) and polyethylene with breakthrough times of 8 and 4 hr, respectively. **Ventilation:** Provide general and local explosion-proof exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local explosion-proof exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Protect containers from physical damage. Store in iron, glass, porcelain or steel containers. Keep small quantities in cool, dry, well-ventilated area away from incompatibles (Sec. 5). Store large quantities in tanks; add water or inert gas (such as nitrogen) to fill emptying tanks. Submerge tanks in water or locate them above concrete basins large enough to hold the tanks' contents. Equip storage facilities with automatic sprinklers and test regularly. Outside or detached storage is preferred.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground all system parts including piping, valves, and moveable containers. Prohibit electrical installations and heating facilities in or near storage areas. Never transfer carbon disulfide by means of air pressure; use pump, water, or inert gas. Use wooden sticks (no spark potential) to measure the contents of CS_2 tanks and containers.

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers that emphasize eyes, skin, CNS, PNS, CVS, and reproductive system, and perform electrocardiograms.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Carbon bisulfide or Carbon disulfide
DOT Hazard Class: Flammable liquid
ID No.: UN1131
DOT Label: Flammable liquid
DOT Packaging Exceptions: None
DOT Packaging Requirements: 173.121

IMO Shipping Name: Carbon disulphide
IMO Hazard Class: 3.1
ID No.: UN1131
IMO Label: Flammable liquid, Poison
IMDG Packaging Group: I

MSDS Collection **References:** 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 136, 140, 149, 153, 159, 162, 163, 164
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH, **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 355
Phenol

Issued: 9/80 Revision: C, 11/90

Section 1. Material Identification

33

Phenol (C_6H_5OH) Description: One of many aromatic compounds in coal tar. Made by alkylating benzene with propylene then oxidizing the resulting cumene to produce phenol and acetone. Used as a feedstock in manufacturing various phenolic resins, caprolactum, bis-phenol-A, and other chemicals and drugs; a disinfectant; a fuel-oil sludge inhibitor; a reagent in chemical analysis; in producing or manufacturing a large variety of aromatic compounds including fertilizers, illuminating gas, coke, explosives, lampblack, paints, paint removers, asbestos goods, wood preservatives, textiles, perfumes, bakelite, rubber, and other plastics; in medical and industrial organic compounds and dyes; and in germicidal paints and slimicides. Phenol has been identified in cigarette smoke and automobile exhaust.

R 1
I 4
S 3*
K 2
* Skin absorption

NFPA

HMIS
H 3
F 2
R 0
PPG†
† Sec. 8

Other Designations: CAS No. 0108-95-2, carbolic acid, hydroxybenzene, monohydroxy benzene, oxybenzene, phenic acid, phenyl alcohol, phenyl hydroxide.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

Cautions: Phenol has a marked corrosive effect on any tissue. Eye contact may cause severe damage and *blindness*. Its primary entry route is through *skin absorption*. Systemic absorption may cause *liver and kidney damage, convulsions (seizures), or death.*

Section 2. Ingredients and Occupational Exposure Limits

Phenol, ca 100%

1989 OSHA PEL (Skin)
8-hr TWA: 5 ppm, 19 mg/m³

1990-91 ACGIH TLV (Skin)
TWA: 5 ppm, 19 mg/m³

1988 NIOSH REL
TWA: 5 ppm, 19 mg/m³
Ceiling: 15.6 ppm, 60 mg/m³

1985-86 Toxicity Data*
Mammal, inhalation, LC_{50}: 74 mg/m³
Rat, oral, LD_{50}: 317 mg/kg; toxic effects include behavorial changes (convulsions or effect on seizure threshold)
Rabbit, eye, TC_{Lo}: 5 mg produces severe irritation

1987 IDLH Level
250 ppm

* See NIOSH, *RTECS* (SJ3325000), for additional irritative, mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 359.15 °F (181.75 °C) at 760 mm Hg
Melting Point: 109.4 °F (43 °C)
Vapor Pressure: 0.3513 mm Hg at 77 °F (25 °C)
Vapor Density (Air = 1): 3.24
pH: 6 (aqueous solution)
Molecular Weight: 94.11
Specific Gravity (20 °C/4 °C): 1.0576
Water Solubility: 1 g dissolves in about 15 ml H_2O
Viscosity: 12.7 centipoise at 64.9 °F (18.3 °C)

Appearance and Odor: White crystalline solid with a characteristic sharp medicinal sweet, tangy odor detectable above 0.05 ppm. Phenol turns pink or red if it contains impurities or is exposed to heat or light.

Section 4. Fire and Explosion Data

Flash Point: 175 °F (79 °C), CC	Autoignition Temperature: 1319 °F (715 °C)	LEL: 1.7% v/v	UEL: 8.6% v/v

Extinguishing Media: Use water spray, carbon dioxide, dry chemical, or alcohol-type foam to extinguish fires involving phenol. Do not use a solid stream of water since the stream scatters and spreads fire. Use water spray to cool fire-exposed tanks/containers.

Unusual Fire or Explosion Hazards: Phenol presents a moderate fire hazard when exposed to heat, flame, or oxidizers. When heated, it emits toxic fumes and vapors that form explosive mixtures with air. Air mixtures containing 3 to 10% phenol are explosive. Solid phenol burns with difficulty, giving off heavy smoke.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective clothing. Be aware of runoff from fire control methods. Water containing phenol can cause severe chemical burns. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Phenol is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: In general, phenol is incompatible with strong oxidizing agents and halogens. It coagulates colodion and proteins. A potentially explosive reaction occurs with formaldehyde, peroxydisulfuric acid, peroxymonosulfuric acid, sodium nitrite + heat, and aluminum chloride + nitromethane (at 110 °C/100 bar). A violent reaction occurs with butadiene, sodium nitrite + trifluoroacetic acid, and aluminum chloride + nitrobenzene at 248 °F (120 °C). Combining phenol with mineral oxidizing acids results in fire; with acetaldehyde results in violent condensation; with isocyanates results in heat generation and violent polymerization, with calcium hypochlorite results in an exothermic reaction producing toxic fumes which may ignite; and with nitrides results in heat and flammable gas generation. Hot phenol is corrosive to many metals, including aluminum, lead, magnesium, and zinc. Reaction with these materials causes phenol to discolor.

Conditions to Avoid: Avoid heating phenol above 122 °F (90 °C).

Hazardous Products of Decomposition: Thermal oxidative decomposition of phenol can produce oxides of carbon and water.

Section 6. Health Hazard Data

Carcinogenicity: The NTP, IARC, and OSHA do not list phenol as a carcinogen. Although no specific evidence of human cancer exists, its carcinogenicity to mice emphasizes the need for precaution when handling this material. Phenol also causes human mutations (genetic changes).

Summary of Risks: Phenol is a general protoplasmic poison that is corrosive to any living tissue it contacts. Toxicity most likely results from dermal (skin) contact or ingestion. Skin absorption occurs readily with a rapid onset of symptoms or death (within 30 min to several hours). Contact with eyes may cause severe damage and blindness. Ingestion of 1 g may be fatal. Although phenol is irritating to the respiratory tract, due to its low volatility and good warning properties, inhalation is typically less of a concern. Chronic toxic effects are uncommon, but may include digestive disturbances, neurological disorders, skin rash (dermatitis), and liver and kidney damage.

Medical Conditions Aggravated by Long-Term Exposure: Individuals with chronic respiratory disorders, pre-existing skin disorders, convulsive disorders, or kidney or liver abnormalities may be at increased risk from phenol exposure.

Target Organs: Liver, kidneys, nervous system, and skin.

Primary Entry Routes: Skin absorption, eye contact, ingestion, and inhalation.

Acute Effects: Skin contact results in white, wrinkled discoloration, followed by a severe burn or systemic poisoning if removed improperly.

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Section 6. Health Hazard Data, *continued*

Phenol ingestion can cause gangrene and corrosion of lips, mouth, throat, esophagus, and stomach if not properly decontaminated (see First Aid). Although not immediately painful, skin contact can cause serious burns and systemic toxicity. In addition to skin burns and respiratory tract irritation, systemic absorption may cause pallor, anorexia (appetite loss), nausea, vomiting, diarrhea, weakness, muscle aches, darkened urine, headache, tinnitus (ringing in ears), sweating, convulsions, cyanosis (bluish coloration of lips and/or fingertips), shock, unconsciousness, respiratory failure, and death. After ingestion, major percutaneous (skin), or inhalation exposures, collapse and death can be rapid. Ingestion can cause severe tissue corrosion or gangrene affecting lips, mouth, throat, esophagus, and stomach. Eye contact can cause severe corrosive damage to the eye (conjunctival edema, corneal opacification, and hypesthesia) and possible blindness.

Chronic Effects: Chronic phenol poisoning is rarely reported. Symptoms include vomiting, difficulty swallowing, diarrhea, appetite loss, headache, fainting, dizziness, darkened urine, and mental disturbances. Chronic exposure can cause death from liver and kidney damage. Repeated skin contact with phenol or phenol-bearing products can result in dermatitis with dark pigmentation (ochronosis) of skin and whites of eyes (sclerae).

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water for at least 15 min. Consult a physician immediately.

Skin: Speedy action is critical. Flood exposed area with water and quickly remove contaminated clothing. *As soon as possible*, repeatedly spray or swab with the decontaminating agent polyethyleneglycol-300 (PEG). Immerse extremities in PEG. Rescue personnel should protect themselves from skin contact with phenol. Do not use greases, powders, or ointments to treat phenol burns. *Never* delay phenol removal if PEG is not readily available. Use soap and water instead.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: *Speed is essential in the treatment of oral poisoning.* Immediately consult a physician and poison center. Never give anything by mouth to an unconscious or convulsing person. Administer to that *conscious* person 15 to 30 cc castor oil or another vegetable oil, and be prepared to induce vomiting upon a physician's advice. Vegetable oils slow phenol absorption and reduce local damage.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Treat ingestion with gastric lavage using 40% aqueous Bacto-Peptone, milk, or water until phenolic odor is eliminated. Then give 15 to 50 cc castor or vegetable oil. Debride necrotic skin. Monitor vital signs, fluid status, electrolytes, BUN, renal and hepatic function, and electrocardiogram. Manage sedation, seizures, renal failure, and fluid electrolyte imbalances symptomatically as indicated.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and skin and eye contact with a self-contained breathing apparatus and full personal protective clothing and equipment. Absorb small spills with some noncombustible inert material and place in a closed metal container for disposal. Dike large spills and allow material to cool and solidify. Using nonsparking tools, shovel solid into steel containers for disposal. Thoroughly flush spill area with water, use caustic soda solution for neutralization, and collect flushings and wash water for disposal. Do not allow phenol to enter sewers, watersheds, or waterways. Follow applicable OSHA regulations (29 CFR 1910.120). Notify proper authorities including the National Response Center (800-424-8802).

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 1000 lb (454 kg) [* per Clean Water Act, Sec. 311(b)(4), Sec. 307(a), and per RCRA, Sec. 3001]

Listed as a SARA Extremely Hazardous Substance (40 CFR 355): RQ, 1000 lb; Threshold Planning Quantity (TPQ), 500/10,000 lb

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Where potential exists for exposures near or over 19 mg/m³, use a MSHA/NIOSH-approved full facepiece respirator with an organic vapor cartridge/canister and dust/mist prefilter. Increased protection is obtained from full facepiece powered-air purifying respirators. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. ACGIH recommends neoprene or butyl rubber as good-to-excellent protective materials.

Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry, well-ventilated area away from heated surfaces, open flame, and ignition sources. Outside or detached storage is preferred. Protect containers from physical damage.

Engineering Controls: Enclose all operations, eliminating all possible phenol exposure routes. Educate workers about phenol's hazards and potential dangers. Use only with appropriate personal protective gear and adequate ventilation. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Provide local exhaust ventilation at the site of chemical release. Practice good personal hygiene and housekeeping procedures.

Medical Surveillance: Provide preplacement or periodic medical examinations that emphasize central nervous system (CNS), hepatic, renal, and skin. Tests should include BUN, creatinine, LFTs, and urinalysis. Phenol can be detected in urine in free or conjugated forms. The ACGIH biological exposure index (BEI) is 250 mg total phenol/g creatinine or 15 mg/hr.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Phenol
DOT Hazard Class: Poison B
ID No.: UN1671
DOT Label: Poison
DOT Packaging Exceptions: 173.364
DOT Packaging Requirements: 173.369

IMO Shipping Name: Phenol
IMO Hazard Class: 6.1
ID No.: UN1671
IMO Label: Poison
IMDG Packaging Group: II

MSDS Collection **References:** 1, 2-12, 15, 19, 23, 24, 26, 31, 34, 37, 38, 59, 73, 79, 84, 85, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138-140, 143, 146, 148, 149

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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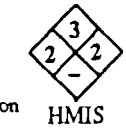
Material Safety Data Sheets Collection:
Sheet No. 351
Styrene *monomer*
Issued: 8/79 Revision: D, 6/92

Section 1. Material Identification

Styrene *monomer* ($C_6H_5CHCH_2$) **Description:** Produced by catalytic dehydrogenation of ethylbenzene at 932 to 1292 °F (500 to 700 °C) at 30 mm Hg; catalyst is a mixture of zinc oxide (86%), aluminum, calcium, and magnesium. Available in technical (99.2% pure) and polymer (99.6% pure) grades. Occurs naturally in the sap of styracaceous plants, in pyrolysis and cracking products of petroleum derivatives, in bituminous-coal and shale-oil tars, in rubber latexes, and as a product of organic substance pyrolysis. Used in the manufacture of a wide range of polymers including polystyrene and copolymer elastomers such as butadiene-styrene rubber or acrylonitrile-butadiene-styrene (ABS); in production of plastics and insulators, as a resin modifying additive, dental filling component, chemical reaction intermediate, and in agricultural products.
Other Designations: CAS No. 100-42-5, cinnamene, Diarex HF 77, ethenylbenzene, NCI-C02200, phenylethylene, styrol, styropor, vinylbenzene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.
Cautions: Styrene is extremely flammable and polymerizes easily. The vapor is irritating to eyes, skin, and respiratory system and the liquid may cause burns. Inhalation of high concentrations can lead to central nervous system (CNS) depression.

R 2
I 3
S 2*
K 3
* Skin absorption

NFPA†



HMIS
H 2
F 3
R 2
PPG‡
‡ Sec. 8
† Rating is for *inhibited* monomer

Section 2. Ingredients and Occupational Exposure Limits

Styrene *monomer*, ca 99.6%, containing inhibitors butylcatechol or hydroquinone

1991 OSHA PELs
8-hr TWA: 50 ppm (215 mg/m³)
15-min STEL: 100 ppm (425 mg/m³)

1990 IDLH Level
5000 ppm

1990 NIOSH RELs
TWA: 50 ppm (215 mg/m³)
STEL: 100 ppm (425 mg/m³)

1991-92 ACGIH TLVs (Skin)
TWA: 50 ppm (213 mg/m³)
STEL: 100 ppm (426 mg/m³)

1990 DFG (Germany) MAKs
Ceiling: 20 ppm (85 mg/m³)
Half-life: < 2 hr
Peak Exposure Limit: 40 ppm, 30 min. average value, 4 per shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 20 µg/m³ caused eye effects.
Human, skin: 500 mg (non-standard test, *accident*) caused irritation.
Human, HeLa cell: 28 mmol/L caused unscheduled DNA synthesis.
Rat, oral, LD_{50}: 5000 mg/kg; toxic effects not yet reviewed
Rat, inhalation, LC_{50}: 24 g/m³/ 4 hr produced an antipsychotic effect.

* See NIOSH, *RTECS* (WL3675000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 293 °F (145 °C)
Freezing Point: -23 °F (-31 °C)
Vapor Pressure: 5 mm Hg at 68 °F (20 °C)
Viscosity: 0.751 mPa
Refraction Index: 1.5463 at 68 °F (20 °C)
Odor Threshold Range: 0.15 to 25 ppm
Density: 0.9045 at 25/25 °C

Surface Tension: 32.14 dyne/cm at 66.2 °F (19 °C)
Molecular Weight: 104.2
Saturated Vapor Density (air = 1.2 kg/m³): 1.22 kg/m³ or 0.076 lbs/ft³
Water Solubility: Practically insoluble, 0.3 lbs/100 lbs water; floats on water
Other Solubilities: Soluble in benzene, carbon disulfide, carbon tetrachloride, ethanol, ethyl ether and ketones. Dissolves organic substances and polymers.

Appearance and Odor: Colorless to slightly yellow oily liquid with a sweet, pleasant odor at low levels becoming pungent as levels increase.

Section 4. Fire and Explosion Data

Flash Point: 88 °F (31 °C), CC	Autoignition Temperature: 914 °F (490 °C)	LEL: 1.1% v/v	UEL: 7% v/v

Extinguishing Media: A Class 1C flammable liquid. For small fires, use dry chemical, carbon dioxide (CO_2), or regular foam. For large fires, use fog, or regular foam. Water may be ineffective since styrene tends to float on water; use only when other agents are unavailable.
Unusual Fire or Explosion Hazards: Styrene may accumulate static electricity. Hazardous polymerization can occur causing container to rupture due to heat of fire. Vapors may travel to ignition source and flash back. Styrene poses a vapor explosion hazard indoors, outdoors, and in sewers.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Use protective clothing specifically recommended by manufacturer. Apply cooling water to container sides until well after fire is out. If possible without risk, remove container from fire area. Stay away from ends of tanks. For massive fire in cargo area use monitor nozzles or unmanned hose holders; if this is impossible, withdraw from area and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Uninhibited styrene monomer is very unstable and even when inhibited (butylcatechol or hydroquinone) polymerization occurs slowly at room temperature and fast at elevated temperatures or in contact with certain initiators. **Chemical Incompatibilities:** Styrene vapor is explosive when exposed to heat or flame; reacts with oxygen above 104 °F (40 °C) to form a heat-sensitive explosive peroxide. Violent polymerization may be initiated by alkali metal-graphite composites, butyllithium, dibenzoyl peroxide, azoisobutyronitrile or di-*tert*-butyl peroxide. Styrene reacts violently with chlorosulfonic acid, oleum, sulfuric acid, chlorine + iron (II) chloride (above 50 °C) and can react vigorously with oxidizing materials. **Conditions to Avoid:** Exposure to heat and ignition sources, light, and contact with incompatibles.
Hazardous Decomposition Products: Thermal oxidative decomposition of styrene can produce carbon dioxide, acrid smoke and irritating fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC(164) lists styrene monomer as a carcinogen; Class 2B (possibly carcinogenic, limited human evidence in the absence of sufficient animal data). **Summary of Risks:** Styrene is irritating to the eyes, skin, and respiratory system. It is absorbed through the skin at 9 to 15 mg/m²/hr (hand and forearm). Inhalation of high concentrations can cause CNS depression but styrene's pungent, irritating odor is usually enough to prevent acute toxic exposures. If heavy exposure occurs, styrene can saturate the body in 30-40 minutes, is distributed throughout the organs and is rapidly eliminated (~85% in 24 hr) either in urine (71%) or expired air (10%). Unexcreted styrene accumulates in adipose tissue (subcutaneous connective tissue containing fat cells). Ovulation and menstrual disorders were observed in women exposed to styrene. In one case, CNS effects were observed in infants whose mother was exposed to chemicals such as styrene during pregnancy. In general, pregnant women may be at elevated risk because styrene crosses the placental barrier. **Target Organs:** CNS, eyes, respiratory system, and skin. **Primary Entry Routes:** Inhalation, skin contact/absorption. **Medical Conditions Aggravated by Long-term Exposure:** Possibly, liver, kidney, blood, skin, and CNS disorders.
Acute Effects: Inhalation of concentrations as low as 50 ppm causes irritation of the eyes, and respiratory tract.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Symptoms include watering eyes and nose, chest heaviness or pain, difficulty breathing, coughing, bluish face and lips, wheezing, headache, nausea, vomiting, dizziness, fatigue, diarrhea and risk of pulmonary edema (fluid in lungs). Skin contact is irritating, with itching, inflammation and possible blisters. Splashes to the eyes cause irritation, watering, lid inflammation, chemical corneal burns, and possibly, serious lesions. Cases of ingestion have not been reported but by analogy to animal studies it could cause irritation of the lips, mouth, and throat; painful swallowing, abdominal pain, nausea, vomiting, state of shock, possible convulsions and risk of pulmonary edema. **Chronic Effects:** Repeated exposure has caused "styrene sickness" described by nausea, vomiting, appetite loss, and general weakness. Occupational asthma may occur rarely. Functional disorders of the nervous system, irritation of the upper airways, and blood changes particularly leukopenia (abnormally low number of circulating, nucleated white or colorless blood cells) and lymphocytosis (increased number of lymphocytes which are involved in the immune system) have also been observed. Medical exams revealed toxic hepatitis in workers exposed to ~50 mg/m^3 styrene for over 5 yr. Prolonged exposure to < 50 mg/m^3 caused certain liver function disorders (protein, pigment, glycogen). Peripheral neuropathies were observed in chronically exposed workers. Repeated or prolonged skin exposure may cause dermatitis with rough, dry, fissured skin due to defatting.

FIRST AID Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Do *not* allow victim to rub or keep eyes tightly shut. Immediately consult a physician. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not induce vomiting!* Gastric lavage may be indicated if victim is at risk of convulsing but the decision should be carefully weighed since severe esophageal irritation may occur. **Note to Physicians:** For acute exposure, give baseline liver and kidney function tests and obtain urinalysis, CBC, amylase and lipase levels. Monitor arterial blood gases and perform chest X-ray if significant respiratory irritation occurs. Phenylglyoxylic and mandelic acid may be determined in urine.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel should protect against inhalation and eye and skin contact. Shut off all ignition sources. Use water spray to cool and disperse vapors (this may not prevent ignition in closed spaces). For small spill, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. For large spills, dike far ahead of liquid spill for later disposal or reclamation. For spills in water, apply activated carbon at 10 X the spilled amount (at least 10,000 ppm) or use barriers or oil spill booms to limit motion. "Universal" gelling agent injected into spill may aid in solidification. Remove material with suction hoses or mechanical dredges. Follow applicable OSHA regulations (29 CFR 1910.120). Report spills in excess of 1000 lb. **Ecotoxicity Values:** TLm, *Pimephales promelas* (fathead minnow), 53.6 mg/L/48 hr; TLm, *Artemia salina* (brine shrimp), 68 mg/L/24 hr and 52 mg/L/48 hr. **Environmental Degradation:** In water, styrene monomer volatilizes rapidly and may be subjected to biodegradation. It is not expected to hydrolyze. In air, styrene will react rapidly with hydroxyl radicals and ozone with a combined calculated half-life of 2.5 to 9 hr. In soil, styrene will biodegrade and leach to groundwater with low to moderate mobility (depending on soil conditions). **Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations Listed as a RCRA Hazardous Waste (40 CFR 261.21 & 261.23): D001 and D003, Characteristic of ignitability and reactivity
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311(b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A & Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH/MSHA-approved respirator. For < 500 ppm, use any supplied air respirator (SAR) or SCBA. For < 1250 ppm, use any SAR operated in a continuous flow mode. For < 5000 ppm, use any SAR with a full facepiece in positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol is recommended as suitable material for PPG. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Thoroughly decontaminate PPG. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Styrene is corrosive to copper or copper alloy containers. Store in cool (hazardous above 32 °C), dry, well-ventilated area away from incompatibles (Sec. 5). Store small refrigerated amounts in glass containers and large amounts in vented metal tanks in outside or detached storage under an inert blanket (i.e., nitrogen). Install electrical equipment Class 1, Group D. Inhibit styrene during storage to prevent polymerization. Uninhibited vapor may polymerize in vents and cause blockage. To prevent static sparks, electrically ground and bond all equipment used in styrene manufacture, use, storage, transfer, and shipping. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Continuously monitor workplace air levels of styrene. Make sure ducting, piping, and pipe joints are leak tight. Give preference to continuous rather than batch techniques and mechanize manual operations. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, blood, liver, kidney, and skin. Consider precluding pregnant women from styrene exposure.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Styrene monomer, inhibited
DOT Hazard Class: Flammable liquid
ID No.: UN2055
DOT Label: Flammable liquid
DOT Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Styrene monomer, inhibited
IMO Hazard Class: 3.3
ID No.: UN2055
IMO Label: Flammable liquid
IMDG Packaging Group: II

MSDS Collection **References:** 73, 89, 100, 101, 103, 124, 126, 127, 131, 132, 133, 136, 139, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 357
ISOPHORONE
(Revision C)

Issued: July 1979
Revised: August 1987

SECTION 1. MATERIAL IDENTIFICATION

MATERIAL NAME: ISOPHORONE

OTHER DESIGNATIONS: $COCHC(CH_3)\ CH_2\ C(CH_3)_2\ CH_2$; 3,5,5,-Trimethyl-2-Cyclohexan-1-One; Isoacetophorone; ASTM D 2916; NIOSH RTECS #GW7700000; CAS #0078-59-1

MANUFACTURER/SUPPLIER: This material is available from several suppliers, including: Ashland Chemical Co., Industrial Chemicals & Solvents Division, PO Box 2219, Columbus, OH 43216; Telephone: (614) 889-3844
Aceto Corporation, 126-02 Northern Blvd., Flushing, NY 11368; Telephone: (718) 898-2300

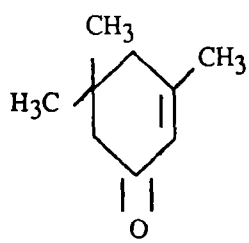
COMMENTS: Isophorone vapors are an irritant with potential toxic kidney effects.

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

* See sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Isophorone, CAS #0078-59-1, NIOSH *RTECS* #GW7700000	ca 100	1987-88 ACGIH Value Ceiling Limit: 5 ppm, 25 mg/m^3* 1986 OSHA PEL (29 CFR 1910. Subpart Z) 8-Hr TWA: 25 ppm, 140 mg/m^3 NIOSH-Recommended Exposure Limit 10-Hr TWA: 4 ppm, 23 mg/m^3 Immediately Dangerous to Life or Health (IDLH) Level: 800 ppm Toxic Dose Human, Inhalation, TC_{Lo}: 25 ppm (Systemic Irritant Effects) Rat, Oral, LD_{50}: 2330 mg/kg Primary Irritation Dose Human, Eye: 25 ppm/15 min



* The ACGIH ceiling limit is set to prevent irritative and narcotic effects.

SECTION 3. PHYSICAL DATA

Boiling Point ... 419°F (215°C)
Vapor Pressure ... <1 Torr at 68°F (20°C)
Vapor Density (Air = 1) ... 4.8
Solubility in Water ... 1.2% at 68°F (20°C)
Specific Gravity ... 0.92 at 68°F (20°C)
Freezing Point ... 17.42°F (-8.1°C)
Evaporation Rate (nBuAc = 1) ... 0.03
% Volatile ... ca 100
Molecular Weight ... 138.23 Grams/Mole

Appearance and odor: Colorless, clear liquid. Peppermintlike or camphorlike odor. Unfatigued, odor-recognition threshold is 0.54 ppm in air (100% test panel).

COMMENTS: Isophorone has a low vapor pressure, and unless it is heated (or sprayed) hazardous concentrations of vapor are not expected to be readily generated.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
		% by Volume		
184°F (84°C)	860°F (460°C)		0.8	3.8

EXTINGUISHING MEDIA: Dry chemical, carbon dioxide, alcohol foam, water spray. Use water spray to cool fire-exposed containers and surrounding combustibles. Use a smothering technique to extinguish fire. UNUSUAL FIRE/EXPLOSION HAZARDS: Vapors are heavier than air and can flow along surfaces to ignition sources and flash back. This material is a moderate fire hazard when exposed to heat or flame. Use water spray to flush solvent away from hazardous exposure. SPECIAL FIRE-FIGHTING PROCEDURES: Wear a self-contained breathing apparatus with full a facepiece operated in a pressure-demand or another positive pressure mode.

SECTION 5. REACTIVITY DATA

Isophorone is a stable material in closed containers at room temperature under normal storage and handling conditions. It does not polymerize.

CHEMICAL INCOMPATIBILITIES: This material is an OSHA Class IIIA combustible liquid. It is incompatible with oxidizing agents such as nitric or sulfuric acid.

CONDITIONS TO AVOID: Isophorone has been reported to readily undergo autoxidation to produce peroxides (Ref. 25, p. 154). If peroxides have formed, minimize physical shocks to the material to reduce explosion hazards. HAZARDOUS DECOMPOSITION PRODUCTS: Products of thermal-oxidative degradation can include carbon monoxide and/or carbon dioxide.

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SECTION 6. HEALTH HAZARD INFORMATION

Isophorone is not listed as a carcinogen by the IARC, NTP, or OSHA.
SUMMARY OF RISKS: Concentrations of this material from 200 to 400 ppm cause nausea, headache, dizziness, faintness, inebriation, and a feeling of suffocation. Isophorone has a low vapor pressure, and unless it is heated (or sprayed), hazardous concentrations of vapor are not expected to be readily generated. Vapors of moderately high concentrations may cause irritation of the nose and throat. Skin contact will cause reddening, defatting, and irritation from prolonged contact. Vapors mildly irritate the eyes; liquid contact with eyes may cause severe eye injury. Isophorone can cause irritation, lacrimation, possible opacity of the cornea, and necrosis of the cornea. TARGET ORGANS: It is chiefly a kidney poison. Respiratory system, skin. PRIMARY ENTRY: Inhalation, contact. ACUTE EFFECTS: Dermatitis results from skin contact. The acute effects of inhalation include irritation to the eyes, nose, and throat; narcosis; inebriation; headache; and dizziness. Workers exposed to 5 to 8 ppm complained of fatigue and malaise. Liver and kidney damage are a risk.
CHRONIC EFFECTS: Not found. MEDICAL CONDITIONS AGGRAVATED BY LONG-TERM EXPOSURE: 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: Remove contaminated clothing. Flush affected area with water; wash with soap and water. Get medical help.* INHALATION: Remove victim to fresh air. Restore and/or support his breathing as required. Get medical help.* INGESTION: Rinse victim's mouth with water. Give him 2 to 3 glasses of water to drink. Get medical help.* This material is an aspiration hazard. Never give anything by mouth to someone who is unconscious or convulsing.
* GET MEDICAL ASSISTANCE = IN PLANT, PARAMEDIC, COMMUNITY. Get medical help for further treatment, observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK: Notify safety personnel and implement containment procedures for isophorone leaks or spills. Remove sources of heat or ignition. Cleanup personnel should use protection against inhalation of vapors and contact with liquid. When necessary, contain spills, using an absorbent material (dry sand or vermiculite). Mix waste and absorbent well and place mixture in an appropriate container for disposal. Flush trace residue with a large amount of water. Do not flush waste to sewers or open waterways. DISPOSAL: Burn waste in an approved incinerator equipped with an afterburner and scrubber. Follow Federal, state, and local regulations.
EPA Hazardous Waste Number (40 CFR 261): Not Listed
Isophorone is not designated as a hazardous substance by the EPA (40 CFR 116.4).
Isophorone is reported in the 1980 EPA TSCA Inventory.
EPA Reportable Quantity (40 CFR 117.3): *Not Listed* Aquatic Toxicity Rating TLm 96: Not Listed

SECTION 8. SPECIAL PROTECTION INFORMATION

GOGGLES: Wear chemical safety goggles or eyeglasses for protection. GLOVES: Wear rubber gloves for protection.
RESPIRATOR: Wear a NIOSH-approved respirator. For emergency IDLH conditions use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive-pressure modes. WORKPLACE CONSIDERATIONS/ VENTILATION: Provide general and local exhaust-fume-ventilation systems to maintain the airborne concentrations below the ACGIH TLV of 5 ppm (25 mg/m^3). OTHER: Vapors are heavier than air and will collect in low-lying areas. CAUTION: These low-lying vapors may encounter ignition sources and flash back to the source of the isophorone vapors.
SAFETY STATIONS: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling.
CONTAMINATED EQUIPMENT: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them.
SPECIAL CONSIDERATIONS: Wear boots, an apron, and other protective clothing suitable for use conditions to prevent contact with skin. Remove contaminated clothing and launder it before wearing it again. Discard contaminated shoes.
COMMENTS: Practice good personal hygiene. Keep materials off of your clothes and equipment. Avoid transferring materials from hands to mouth while eating, drinking, or smoking.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

STORAGE SEGREGATION: Store isophorone in tightly closed containers in a cool, dry, well-ventilated area away from oxidizing agents and sources of heat or ignition. Protect containers from physical damage. SPECIAL HANDLING/STORAGE: Store and handle this material in accordance with requirements for an OSHA class IIIA combustible liquid.
COMMENTS: Avoid breathing isophorone vapors or this material's contact with skin, eyes, or clothing. Practice good personal hygiene. Wash thoroughly after handling it. Do not eat it.

TRANSPORTATION DATA (per 40 CFR 172.101-2):
DOT Shipping Name: Combustible Liquid, NOS
DOT ID No. NA1993
Additional DOT Requirements: None Listed
DOT Hazard Class: Combustible Liquid
DOT Required Label: None

References: 1-4, 6-9, 12, 19-21, 23, 25-27, 31, 73, 82, 87-102. CK

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Approvals JO. DeRocco
Indust. Hygiene/Safety N.V. 11-18-87
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Material Safety Data Sheets Collection:

Sheet No. 358
***o*-Dichlorobenzene**

Issued: 11/77 Revision: C, 8/90

Section 1. Material Identification

***o*-Dichlorobenzene ($C_6H_4Cl_2$) Description:** Prepared by the chlorination of benzene or monochlorobenzene in the presence of a catalyst. Used as a solvent for waxes, gums, tars, resins, oils, and asphalts; an insecticide for locust borers and termites; a degreasing agent for metals, leather, and wool; an intermediate in manufacturing dyes; an ingredient of metal polishes; an industrial odor control; a heat transfer medium; and in removing sulfur from illuminating gas.
Other Designations: CAS No. 0095-50-1, DCB, 1,2-dichlorobenzene, orthodichlorobenzene.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.

R 1
I 3
S 2*
K 2
* Skin absorption

NFPA

HMIS
H 2
F 2
R 0
PPG*
* Sec. 8

Caution: *o*-Dichlorobenzene is a local irritant, a strong central nervous system (CNS) depressant, and a liver and kidney poison.

Section 2. Ingredients and Occupational Exposure Limits

o-Dichlorobenzene*

1989 OSHA PEL
15-min STEL (ceiling): 50 ppm, 300 mg/m³

1989-90 ACGIH
TLV-STEL (ceiling): 50 ppm, 301 mg/m³

1985-86 Toxicity Data†
Rat, inhalation, LC_{Lo}: 821 ppm inhaled over 7 hr produces changes in behavior (general anesthetic), liver (hepatitis: hepatocellular necrosis, zonal) and sense organs, and special senses (tearing)
Rat, oral, LD_{50}: 500 mg/kg; toxic effects not yet reviewed
Rabbit, eye: 100 mg/30-s rinse produces mild irritation

1987 IDLH Level
1700 ppm

1988 NIOSH REL
None established

* This material may contain some impurities. It is at least 85% *o*-dichlorobenzene, but may contain varying percentages of *para*- and *meta*-dichlorobenzene.
† See NIOSH, *RTECS* (CZ4500000), for additional irritative, mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 356.9 °F (180.5 °C) at 760 mm Hg
Melting Point: 1.4 °F (-17 °C)
Vapor Pressure: 1.47 mm Hg at 25 °C
Vapor Density (Air = 1): 5.05
Molecular Weight: 147.01
Specific Gravity 20°C/4°C: 1.3059
Water Solubility: Practically insoluble (137 mg/liter at 25°C)
% Volatile by Volume: ca 100
Evaporation Rate (BuAc = 1): <1

Appearance and Odor: A colorless liquid with a disagreeable, aromatic odor. The high and low odor thresholds are 300 and 12 mg/m³; *o*-dichlorobenzene is irritating at 150 mg/m³. The odor is perceptible at 2 to 4 ppm.

Section 4. Fire and Explosion Data

Flash Point: 151°F (66 °C), CC	Autoignition Temperature: 1198 °F (648 °C)	LEL: 2.2% v/v	UEL: 9.2% v/v

Extinguishing Media: Extinguish fires involving this combustible material with water spray, dry chemical, foam, or carbon dioxide.
Unusual Fire or Explosion Hazards: Under normal working conditions, *o*-dichlorobenzene should not pose a fire hazard because of its high flash point. However, explosive mixtures may form if this material is heated or in a fire situation.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and a fully encapsulating suit. Use water to cool fire-exposed containers, to flush spills away from exposures, and to protect workers attempting to stop a leak. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: *o*-Dichlorobenzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: This material can react vigorously with oxidizing materials. If *o*-dichlorobenzene is stored in sealed aluminum containers, a slow reaction with the aluminum could lead to an explosion.
Conditions to Avoid: Avoid heat and hot surfaces.
Hazardous Products of Decomposition: Thermal oxidative decomposition of *o*-dichlorobenzene can emit toxic fumes of chlorine (Cl^-).

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Section 6. Health Hazard Data

Carcinogenicity: The IARC does not list *o*-dichlorobenzene as a carcinogen because of inadequate human and animal evidence. However, other sources identify *o*-dichlorobenzene as a suspected carcinogen.[126] Experimental studies show *o*-dichlorobenzene has teratogenic, mutagenic, and reproductive effects in laboratory animals.
Summary of Risks: This material is a skin, eye, and mucous membrane irritant. Noticeable eye irritation at 25 to 30 ppm is reported after a few minutes' exposure; at 60- to 100-ppm exposure levels eye irritation becomes painful. Voluntary overexposure is unlikely due to good warning properties (odor, eye, and respiratory irritation). Excessive vapor inhalation can cause drunkenness, anesthetic effect, and central nervous system (CNS) depression.
Medical Conditions Aggravated by Long-Term Exposure: Toxic effects can include hematological (blood) disorders and liver and kidney damage. Leukemia has been reported, but with no definite link to *o*-dichlorobenzene.
Target Organs: Liver, kidneys, skin, eyes.
Primary Entry Routes: Inhalation, skin absorption.
Acute Effects: Inhalation causes nose, eye, and throat irritation. Liquid contact with skin causes irritation. Prolonged or repeated contact may cause blister formation. Ingestion of *o*-dichlorobenzene causes burning pain in the stomach, nausea, vomiting, and diarrhea.
Chronic Effects: Symptoms include headache, anorexia, nausea, vomiting, weight loss, jaundice, and cirrhosis.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 2 to 3 glasses of water or milk to dilute. Spontaneous vomiting may occur. Position to prevent aspiration and observe for signs of breathing difficulty and change in consciousness. Contact a physician immediately.
Physician's Note: There is a chemical aspiration hazard if vomiting is induced; treat symptomatically. Serum hydrocarbon levels are not clinically useful since they reflect cumulative, rather than acute, exposure and may be misleading. The National Pesticide Telecommunications Network (800-858-7378) provides 24-hr consultation to health professionals.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, remove all heat and ignition sources, provide adequate ventilation, and evacuate all unnecessary personnel. Cleanup personnel should protect against vapor inhalation and contact with skin or eyes. Contain spills by diking. Collect liquid if feasible. Absorb small spills and residues on sand or vermiculite and place in a closed metal drum for disposal or reclamation. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), No. *U070*
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per Clean Water Act, Sec. 311(b)(4) and Sec. 307(a); per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. A chemical cartridge respirator with an organic vapor cartridge and full facepiece can be used below 1000 ppm. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. Neoprene or vinyl gloves are recommended.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry, well-ventilated area away from oxidizing agents and heat and ignition sources. Outside or detached storage is preferred. Protect containers from physical damage. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas.
Engineering Controls: Avoid vapor inhalation and contact with eyes and skin. Use only with personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide a preplacement questionnaire with emphasis on detecting a history of skin, liver, or kidney disease. Such individuals may be at an increased risk from exposure. Individuals may develop tolerance to high levels of exposure.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Dichlorobenzene, ortho, liquid
DOT Hazard Class: ORM-A
ID No.: UN1591
DOT Label: None
DOT Packaging Requirements: 173.510
DOT Packaging Exceptions: 173.505

IMO Shipping Name: *o*-Dichlorobenzene
IMO Hazard Class: 6.1
IMO Label: St. Andrews Cross
IMDG Packaging Group: III
ID No.: UN1591

***MSDS Collection* References:** 38, 73, 84, 85, 88, 89, 100, 101, 103, 109, 124-127, 129, 132, 133-136, 138
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

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

SECTION 1. MATERIAL IDENTIFICATION

23

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

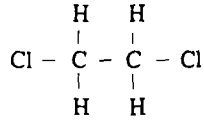
HMIS	
H	1
F	3
R	0
PPE*	
R	1
I	4
S	2
K	4

* See Sect. 8

COMMENTS: Ethylene dichloride is a flammable, toxic liquid.

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.

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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 JO. Accocco

Indust. Hygiene/Safety 11-18-87

Medical Review 11-30-87

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Material Safety Data Sheets Collection:

Sheet No. 366
Chlorobenzene

Issued: 11/82 Revision: B, 11/90

Section 1. Material Identification

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Chlorobenzene (C_6H_5Cl) Description: Produced by chlorinating benzene in the presence of a catalyst. Used in dry cleaning; as a solvent in manufacturing paints, adhesives, polishes, waxes, diisocyanates, natural rubber, and pharmaceuticals; a chemical intermediate for phenol, *o*-, and *p*-chloronitrobenzene, DDT, and aniline; and an intermediate in manufacturing dyestuffs.

Other Designations: CAS No. 0108-90-7, benzene chloride; chlorobenzol; MCB; monochlorobenzene; phenyl chloride.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

R 1
I 3
S 2
K 3

NFPA

HMIS
H 2
F 3
R 0
PPG*
* Sec. 8

Cautions: Chlorobenzene is a skin and mucous membrane irritant, a fairly strong narcotic, and a central nervous system (CNS) depressant. Chronic inhalation may cause *lung, liver, and kidney damage*. This material is a dangerous fire hazard when exposed to heat or flame.

Section 2. Ingredients and Occupational Exposure Limits

Chlorobenzene, ca 100%

1989 OSHA PEL	1990-91 ACGIH TLV*	1988 NIOSH REL	1985-86 Toxicity Data†
8-hr TWA: 75 ppm, 350 mg/m³	TWA: 75 ppm, 345 mg/m³	None established	Rat, oral, LD_{50}: 2910 mg/kg; toxic effects not yet reviewed Rat, inhalation, TC_{Lo}: 210 ppm administered for 6 hr to a 6- to 15-day pregnant female produces specific developmental abnormalities

1987 IDLH Level
2400 ppm

* In its "Notice of Intended Changes (for 1990-91)," the ACGIH lists a proposed lower level TWA for chlorobenzene: 10 ppm, 46 mg/m³.[150]
†See NIOSH, *RTECS* (CZ0175000), for additional mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 270 °F (132 °C) at 760 mm Hg
Melting Point: -50.1 °F (-45.6 °C)
Vapor Pressure: 11.8 mm Hg at 77 °F (25 °C)
Vapor Density (Air = 1): 3.88
Viscosity: 0.790 centipoise at 70 °F (21 °C)
Molecular Weight: 112.56
Specific Gravity (20 °C/4 °C): 1.1058
Water Solubility: Insoluble

Appearance and Odor: A clear, colorless, volatile liquid with a faint, almond-like odor. Threshold odor concentration: 100% recognition, 0.21 ppm.

Section 4. Fire and Explosion Data

Flash Point: 85 °F (29.5 °C), CC	Autoignition Temperature: 1180 °F (638 °C)	LEL: 1.8% v/v	UEL: 9.6% v/v

Extinguishing Media: Use carbon dioxide, dry chemical, halon, water spray, or standard foam to extinguish fires involving chlorobenzene. Use water in flooding quantities as fog since solid streams of water may spread fire. Apply water spray from as far as possible to cool fire-exposed containers.

Unusual Fire or Explosion Hazards: Chlorobenzene is dangerous when exposed to heat or flame. Vapor may travel to an ignition source and flash back.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Do not extinguish fire unless flow can be stopped. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Chlorobenzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Chlorobenzene is incompatible with strong oxidizers; contact may cause fires and explosions. It reacts violently with dimethyl sulfoxide. Silver perchlorate forms a solvated, shock-sensitive salt with chlorobenzene (explosion). Chlorobenzene is potentially explosive with powdered sodium or phosphorus trichloride + sodium.

Conditions to Avoid: Avoid all heat and ignition sources and incompatible materials.

Hazardous Products of Decomposition: Thermal oxidative decomposition products of chlorobenzene can include soot, hydrogen chloride, phosgene, and carbon monoxide.

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Section 6. Health Hazard Data

Carcinogenicity: The NTP, IARC, and OSHA do not list chlorobenzene as a carcinogen.
Summary of Risks: Chlorobenzene is a fairly strong narcotic and can cause central nervous system (CNS) depression. Overexposure is irritating to the eyes, nasal passages, and upper respiratory tract. It is moderately toxic by inhalation or ingestion and can be absorbed slowly through the skin. Short exposures to liquid may cause skin irritation and defatting, while prolonged or repeated skin contact may result in dermatitis or skin burns. Following absorption of toxic doses, liver and kidney degeneration are also observed. Chlorobenzene may also cause hemolysis.
Medical Conditions Aggravated by Long-Term Exposure: Individuals with skin, liver, kidney, or chronic respiratory disease may be at increased risk from exposure.
Target Organs: Respiratory system, eyes, skin, central nervous system, and liver.
Primary Entry Routes: Inhalation, ingestion, eye and skin contact.
Acute Effects: Symptoms to be expected from acute exposure are headache, eye and upper respiratory tract irritation, dizziness, drowsiness, cyanosis, spastic contractions of extremities, and loss of consciousness, depending on the exposure's concentration and duration. Symptoms of ingestion include pallor, cyanosis, and coma, followed by complete recovery.
Chronic Effects: Frequently repeated contact with chlorobenzene may result in skin burns, eye and upper respiratory tract irritation, headaches, dizziness, somnolence, and dyspeptic disorders (indigestion). Chronic inhalation may result in lung, liver, and kidney damage.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water. Consult a physician immediately. If vomiting occurs, administer more water.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: In a *conscious* patient, attempt to induce vomiting with Syrup of Ipecac. Consider activated charcoal cathartic. Administer charcoal slurry with saline, water, or sorbitol. In an *unconscious* patient, do gastric lavage with suction.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a chlorobenzene spill control and counter measure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel, eliminate all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and contact with liquid. Take up spilled material with a noncombustible absorbent material and place into containers for disposal. For large spills, dike far ahead of spill to contain. Do not release runoff to sewers or waterways since chlorobenzene is harmful to aquatic life in very low concentrations. Aquatic toxicity: A 20-ppm concentration of chlorobenzene administered to bluegill in fresh water during a 96-hr test period is the median tolerance limit (TLm) at which 50% of the aquatic organisms survive. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U037
CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per Clean Water Act, Sec. 311(b)(4), Sec. 307(a), and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Use an organic vapor-acid gas respirator where appropriate. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets (polyvinyl alcohol is recommended) to prevent prolonged or repeated skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a well-ventilated, fire-resistant area away from heat and ignition sources and oxidizing agents. Outside or detached storage is preferred. Storage and handling must be suitable for an OSHA Class IC flammable liquid. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. Protect containers from physical damage.
Engineering Controls: Avoid vapor inhalation and contact with liquid. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide a preplacement questionnaire that emphasizes detecting a history of skin, liver, kidney, or chronic respiratory disease.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Chlorobenzene
DOT Hazard Class: Flammable liquid
ID No.: UN1134
DOT Label: Flammable liquid
DOT Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Chlorobenzene
IMO Hazard Class: 3.3
ID No.: UN1134
IMO Label: Flammable liquid
IMDG Packaging Group: II

MSDS Collection **References:** 38, 73, 84, 85, 89, 100, 101, 103, 124, 126, 131, 132, 133, 136, 138, 139, 140, 143, 146, 148
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 373
Methyl Chloride

Issued: 5/81 Revision: B, 3/92

Section 1. Material Identification

Methyl Chloride (CH_3Cl) Description: Derived by chlorination of methane or by action of hydrochloric acid on methanol in either the liquid or vapor phase. Available in a pure form, technical grade, and two refrigerant grades. Used principally as an intermediate in industrial synthesis such as the manufacture of silicones, butyl rubber, tetramethyl lead, methyl cellulose, dyes, perfumes, and quaternary drugs; as a methylating and chlorinating agent in organic chemistry; in petroleum refineries as an extractant for greases, oils, and resins; as an anti-knock agent; and as a propellant in polystyrene foam production. Formerly used (still in other countries) as a refrigerant, and a local anesthetic.

R 1
I 3
S 2*
K 4
* Skin absorption

NFPA
4
2 0
-

HMIS
H 2
F 4
R 0
PPG†
† Sec. 8

Other Designations: CAS No. 74-87-3, Artic, chloromethane, monochloromethane.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Methyl chloride is extremely flammable. It is an acute central nervous system (CNS) depressant, and can produce chronic liver, kidney, and neurological damage.

Section 2. Ingredients and Occupational Exposure Limits

Methyl chloride (pure grade), ca 99.5%. Most likely contaminants are water vapor and hydrogen chloride gas.

1990 OSHA PELs
8-hr TWA: 50 ppm (105 mg/m³)
15-min STEL: 100 ppm (205 mg/m³)
1990 IDLH Level
10,000 ppm
1990 NIOSH REL
Lowest Feasible Concentration
Limit of Quantitation (LOQ): 1.6 ppm

1991-92 ACGIH TLVs (Skin)
TWA: 50 ppm (103 mg/m³)
STEL: 100 ppm (207 mg/m³)
1990 DFG (Germany) MAKs
TWA: 50 ppm (105 mg/m³)
Class B Carcinogen
Half-life: <2 hr
Peak Exposure Limit: 100 ppm/30 min (average value)/2 per shift

1985-86 Toxicity Data*
Human, inhalation, LC_{Lo}: 20,000 ppm/2 hr caused nausea or vomiting, convulsions (effect on seizure threshold) and affected the eyes
Rat, inhalation, TC_{Lo}: 1500 ppm/70-day-old male produced effects on fertility

* See NIOSH, *RTECS* (PA6300000), for additional mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: -10.7 °F (-23.7 °C)
Freezing Point: -142 °F (-97 °C)
Vapor Pressure: 5 atm at 68 °F (20 °C); 760 mm Hg at -10.7 °F (-23.7 °C)
Gas Density (air = 1): 2.47
Refraction Index: 1.3712 at -10.7 °F (-23.7 °C)
Viscosity: 0.1834 cP at 68 °F (20 °C)
Molecular Weight: 50.49
Density: 0.92 at 68 °F (20 °C)
Water Solubility: Slightly soluble, 0.5%
Other Solubilities: Soluble in alcohol, benzene, carbon tetrachloride and ethanol; miscible with chloroform, ether, and glacial acetic acid.
Saturated Vapor Density: 0.6053 lb/ft³ at 65 °F (18.3 °C)

Appearance and Odor: Colorless gas at room temperature (liquid upon compression), with a sweet odor unnoticed at dangerous concentrations.

Section 4. Fire and Explosion Data

Flash Point: -50 °F (-46 °C)	**Autoignition Temperature:** 1170 °F (632 °C)	**LEL:** 8.1% v/v	**UEL:** 17.4% v/v

Extinguishing Media: Methyl chloride is extremely flammable and burns with a smoky flame. For small fires, let burn unless leak can be stopped immediately. For large fires, use flooding quantities of water as fog, or regular foam.
Unusual Fire or Explosion Hazards: Gas may travel to an ignition source and flash back. Container may explode in heat of fire. Methyl chloride poses a gas explosion hazard indoors, outdoors, and in sewers.
Special Fire-fighting Procedures: Since fire produces toxic thermal decomposition products, including hydrogen chloride and phosgene, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is not effective for methyl chloride fires. If possible without risk, remove container from fire area. Apply cooling water to sides of fire-exposed containers until long after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holder; if impossible, withdraw from area and let fire burn. Withdraw from area immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Methyl chloride is stable when dry and at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Ethylene, chemically active metals such as sodium, potassium, powdered aluminum, zinc, and magnesium or sodium-potassium alloys; can explode on contact with interhalogens such as bromine trifluoride or bromine pentafluoride; and hydrolyzes with water to form hydrochloric acid and methanol.
Conditions to Avoid: Exposure to ignition source or contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of methyl chloride above 752 °F (400 °C) or in strong UV light in the presence of air and moisture can produce carbon monoxide (CO), carbon dioxide (CO_2), hydrogen chloride (HCl), and phosgene ($COCl_2$).

Section 6. Health Hazard Data

Carcinogenicity: Methyl chloride carcinogenicity is controversial. These agencies define methyl chloride carcinogenicity: IARC, Class 3 (not classifiable as to human carcinogenicity);[164] Germany (DFG), MAK Class B (justifiably suspected as having carcinogenic potential);[163] and NIOSH, Class X (carcinogen defined without further explanation).[163] The NTP[142] and OSHA[164] do not list methyl chloride as a carcinogen.
Summary of Risks: Methyl chloride is a CNS depressant and can cause kidney and liver damage. Its vapors pose little hazard to eyes or skin, but contact with the liquid can cause frostbite and corneal lesions. In high concentrations it can produce asphyxia by displacing oxygen in the air. The majority of fatalities resulted from leaks or defects in refrigerator plants. Other exposures resulted from sawing or hot wire cutting styrofoam which releases methyl chloride from the foam cells. Recovery begins almost immediately upon removal from exposure, but can be prolonged and permanent neurologic impairment is reported. Chronic effects may last for years. Most cases of intoxication have involved concentrations above 500 ppm. There is human mutagenic (relating to gene mutation in human mammalian cells) and experimental teratogenic (relating to fetotoxicity, musculoskeletal abnormalities in the rat fetus) data on methyl chloride.
Medical Conditions Aggravated by Long-Term Exposure: CNS disorders, anemia, alcoholism, kidney or liver disease.
Target Organs: CNS, liver, kidney, skin.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Primary Entry Routes: Inhalation, skin contact.
Acute Effects: Inhalation symptoms from CNS depression include staggering gait, difficult speech, nausea, vomiting, headache, nystagmus (rapid, involuntary, right to left motion of the eyeballs), dizziness, blurred vision, and, less frequently, coma or convulsive seizures may occur. The "drunken-like" behavior observed in many victims can cause further injury or harm others from resulting incoordination and impaired judgement, especially by mechanical misoperation (car, machinery). Kidney and liver damage resulted from severe acute exposures. Skin contact with liquid methyl chloride may cause frostbite. The liquid may damage eyes causing stinging, inflammation of the lids, cloudiness and opaqueness, and corneal lesions due to inflammation. Ingestion is very unlikely since liquid is very cold (-42 °F boiling point)!
Chronic Effects: Chronic effects are somewhat similar, including anorexia, diminished vision, dizziness, tremor, incoordination, nervousness, emotional instability, and insomnia. Permanent CNS effects may be noted in some patients.
FIRST AID *Emergency personnel should protect against contamination.*
Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Methyl chloride vaporizes easily and poses an inhalation and flammable/explosion hazard. Properly dispose of contaminated clothing. Rinse with flooding amounts of water for at least 15 min. *Do not* use hot or tepid water (especially for frost-bitten areas); water around 42 °F is best for gradual warming. Gently wash exposed area with soap and water. *Do not* rub or apply pressure to affected areas, especially if frostbitten.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Methyl chloride is a gas and cannot be ingested. The ingestion of the compressed gas (liquid) is highly unlikely.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Keep victim under observation since effects may be delayed. Frostbite is possible upon skin contact, treat accordingly. Monitor blood with baseline CBC and obtain hepatic enzyme samples to assess degree of any possible liver injury.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources. If possible without risk, stop leak. Cleanup personnel should wear fully encapsulating, vapor-protective clothing and SCBAs. Use water spray to reduce vapor. For small liquid spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers with a secure lid. For large spills, dike far ahead of spill for later disposal. Be aware that under normal pressure and room temperature methyl chloride is a gas and that ventilation is the best removal method. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Transport: When released to the atmosphere, methyl chloride diffuses upward and reacts with hydroxyl radicals. In water, it volatilizes (half-life: 2.4 hr in a typical river). On land methyl chloride does not significantly absorb to soil. Due to its high vapor pressure it volatilizes or leaches into groundwater where it should very slowly biodegrade or hydrolyze.
Ecotoxicity Values: *Lepomis macrochirus*, LC_{50}, 550 ppm/96 hr; *Menidia beryllina*, LC_{50}, 270 ppm/96 hr.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U045
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001 and CWA, Sec. 307 (a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A and Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For <1000 ppm use any supplied-air respirator. For <5000 ppm use any supplied-air respirator with a full facepiece, helmet, or hood. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. The charcoal in most gas mask cartridges and canisters is not totally effective as a sorbent for methyl chloride.
Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres. If respirators are used, OSHA requires a respiratory protection program that includes at least: medical review, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Other: Wear gloves, boots, aprons, and gauntlets to prevent all skin contact with cryogenic (freezing) chemicals. Polyvinyl alcohol is a recommended material for personal protective gear.
Ventilation: Provide general and local dilution exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). It is best to have in place nonsparking ventilation fans and sealed, spark-proof motors so that in the event of a spill or release, explosions are prevented.
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in cool, dry, well-ventilated area away from ignition sources and incompatibles (Sec. 5). Outside or detached storage is preferred, and steel containers are recommended. Check cylinders and equipment often for leaks.
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. If entering enclosures with high methyl chloride levels, wear appropriate respirators together with a safety belt and lifeline under the supervision of a helper on the outside.
Administrative Controls: Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, blood, kidney and liver disorders. Inform employees of the hazards associated with working with methyl chloride.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Methyl chloride
DOT Hazard Class: Flammable gas
ID No.: UN1063
DOT Label: Flammable gas
DOT Packaging Exceptions: 173.306
DOT Packaging Requirements: 173.304, 173.314, 173.315

IMO Shipping Name: Methyl Chloride
IMO Hazard Class: 2.3
ID No.: UN1063
IMO Label: Poison Gas, Flammable Gas
IMDG Packaging Group: ---

MSDS Collection **References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 131, 132, 133, 136, 139, 140, 148, 149, 153, 159, 162-164, 167
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheet Collection

Lindane **MSDS No. 560**

Date of Preparation: 6/94

Section 1 - Chemical Product and Company Identification 44

Product/Chemical Name: Lindane
Chemical Formula: $C_6H_6Cl_6$
CAS No.: 58-89-9
Synonyms: Agrocide; Devoran; gamma-benzene hexachloride; gamma-BHC; gamma-HCH; 1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer; Kwell; Lentox; Novigam; Streunex
Derivation: Lindane is the gamma isomer of hexachlorocyclohexane, of which there are 4 others (alpha, beta, delta, epsilon). The gamma isomer is found to be the most effective. Produced by reaction of chlorine with excess benzene in the presence of sunlight to give isomeric mixtures, followed by treatment with methanol or acetic acid and then fractional crystallization or chromatographic adsorption to separate the gamma isomer. Lindane is available in emulsifiable concentrates, flowables, wettable powders, oil-base sprays, granules, dusts, or aerosols.
General Use: Lindane is an insecticide. It is used for control of insects on wood, cotton and other foliar plants; treatment of soil and vegetable/fruit seeds; control of termites; and medicinally (1% solutions) to kill lice and mites (scabies) on the human body.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Lindane; the commercial grade (medicinal) contains 99+% gamma isomer (lindane), and the technical grade contains ~ 64% alpha, 10% beta, 13% gamma, 9% delta, and 1% epsilon.

OSHA PEL
8-hr TWA: 0.5 mg/m^3

ACGIH TLV
TWA: 0.5 mg/m^3 (skin)

NIOSH REL
10-hr TWA: 0.5 mg/m^3 (skin)

IDLH Level
1000 mg/m^3

DFG (Germany) MAK
TWA: 0.5 mg/m^3 (skin)
Category III: Substances with systemic effects
Onset of effect: > 2 hr
Half-life> shift length (strongly cumulative)

Peak Exposure Limit:
5 mg/m^3, 30 min. average value, 1/shift

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Lindane exists as a white to yellow crystalline solid with a slight musty odor. It exerts its toxicity primarily on the central nervous system resulting in convulsions and seizures. Inhalation may also cause irritation of the eyes, nose, and throat. Acute toxicity appears to be more prominent than chronic toxicity with this gamma isomer, whereas the other isomers of hexachlorocyclohexane appear to have primarily chronic effects. Lindane is readily absorbed through the skin, but ingestion has resulted in the severest symptoms.

Wilson Risk Scale
R 1
I 3
S 2*
K 0†
*Skin absorption

HMIS
H 3
F 0†
R 0

† If in solution, solvent may elevate the rating to 2.
PPE‡
‡Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin contact/absorption, ingestion.
Target Organs: Eyes, skin, central nervous system, respiratory tract, and possibly (as seen in animals) the liver, kidneys, and blood.
Acute Effects
Inhalation: Can cause irritation of the eyes, nose, and throat, severe headache, nausea and vomiting.
Eye: Irritation. Conjunctivitis can occur from application of 1% solution to eyelashes. Optic atrophy (tissue death) and blindness occurred in one patient with systemic toxicity.
Skin: Skin contact may cause sensitivity reactions. Lindane is easily absorbed through the skin, especially in hot, humid conditions. Systemic effects are similar to those via ingestion (see below). In one case of fatal skin absorption, the autopsy revealed cerebral edema (swelling of the brain), and hemorrhaging with localized tissue anemia of the kidney. Toxic levels absorbed through the skin may be a significant hazard with medicinal use, especially in children.
Ingestion: Toxicity appears to be most severe via ingestion. Toxicity generally occurs at doses > 50 mg (children) or >150 mg (adults). The estimated fatal dose is 600 mg/kg. Symptoms develop rapidly after ingestion of pure lindane and 2 to 12 hr after ingestion of the technical mixture. If fatal, death occurs within 24 hr. Symptoms include malaise, nausea and vomiting, dizziness, diarrhea, agitation, collapse, cyanosis, muscle tremors, violent convulsions, and seizures.
Carcinogenicity: Listed as a carcinogen by the following agencies: IARC (Class 2B), NTP (Class 2), and EPA (Class B2). Not listed as a carcinogen by OSHA. There have been four cases of leukemia in men exposed to lindane (with or without other chemicals).
Medical Conditions Aggravated by Long-Term Exposure: Seizure disorders, especially those treated with phenytoin.

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Chronic Effects: Lindane is suspected of causing aplastic or hypoplastic anemia in many individuals, but this is questionable since in 1/3 of 46 cases of reported bone marrow injury, there was also exposure to other agents including benzene. It is concluded that blood disorders are possible, but generally in hypersensitive individuals. Minor liver damage has been seen in animals but not yet documented in humans. One case of motor neuron disease has been reported from chronic exposure.

Other: Lindane is metabolized to 2,3,4,6-tetrachlorophenol. Its half-life in plasma is 26 hr (IV injection) and 18.2 hr (skin absorption). Lindane is stored in the fat at about the same rate as intake. Maximum storage is reached at 6 weeks and disappears after another 3 weeks. Of all the hexachlorocyclohexane isomers, gamma (lindane) is the least cumulative. Concurrent exposure to cadmium has been shown to inhibit lindane metabolism and increase toxicity and mutagenicity in animals.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.

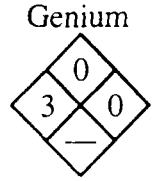
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water to dilute. The decision to induce vomiting should be made on an individual basis; use caution because of the high probability of seizures. Do not administer milk, fatty foods, or oils because they enhance absorption.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Lindane concentration in blood is an indication of extent of absorption. Symptoms (after ingestion/skin absorption of the technical mixture) may be delayed. Perform a CBC including rbc, wbc and differential. Precautions against seizures should be taken in cases of acute exposure.

Section 5 - Fire-Fighting Measures

Genium



Flash Point: Noncombustible. Lindane may be dissolved in a solvent [~ flash point = 150 °F (65.6 °C)].

Autoignition Temperature: Noncombustible.

LEL: None reported.

UEL: None reported.

Extinguishing Media: Use agent suitable for surrounding fire.

Unusual Fire or Explosion Hazards: Container may explode in heat of fire.

Hazardous Combustion Products: Carbon oxides, chlorine, hydrogen chloride, and phosgene gas.

Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways.

Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is *not* effective for protection against lindane. Wear chemical clothing specifically recommended by the shipper or manufacturer.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel should protect against inhalation and skin/eye contact.

Small Spills: Dampen material with alcohol to avoid dust generation. Carefully scoop into vapor-tight plastic bags and seal for later disposal. Dampen a paper towel with alcohol to wipe up any residue.

Large Spills

Containment: Dike far ahead of solution spill for later disposal. Do not release into sewers or waterways.

Cleanup: Wash spill area well with soap and water.

Regulatory Requirements: *Follow applicable OSHA regulations (29 CFR 1910.120).*

Section 7 - Handling and Storage

Handling Precautions: Avoid dust generation.

Storage Requirements: Store in a cool, dry, well-ventilated area away from alkalis and powdered aluminum iron, or zinc.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Enclose all processes where possible to avoid dust dispersion into work area.

Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103)

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the central nervous system, liver, kidneys, and blood.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For ≤ 5 mg/m^3, use any chemical cartridge respirator with a dust, mist, or fume filter, and protection against organic vapors; any supplied-air respirator (SAR); or any

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SCBA. For ≤ 12.5 mg/m^3, use any powered, air-purifying respirator with organic vapor cartridges and a dust, mist, and fume filter, or any SAR operated in continuous flow mode. For ≤ 25 mg/m^3, use any chemical cartridge respirator with a full facepiece, organic vapor cartridges, and a high-efficiency particulate filter; any SCBA or SAR with a full facepiece; any gas, mist, or fume respirator with organic vapor cartridges and a high efficiency particulate filter; or any powered, air purifying respirator with a tight fitting facepiece, organic vapor cartridges and a high-efficiency particulate filter. For ≤ 1000 mg/m^3, use any SAR operated in pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Polycarbonate and butyl rubber are suitable materials for PPE. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove lindane from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using lindane, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Solid

Appearance and Odor: White to yellow, crystalline solid with a slight, musty odor.

Vapor Pressure: 9.4 x 10^{-6} mm Hg at 68 °F (20 °C)

Formula Weight: 290.82

Specific Gravity (H_2O=1, at 4 °C): 1.85

Water Solubility: 0.001%

Octanol/Water Partition Coefficient: log Kow = 3.72

Relative Evaporation Rate: 1.5 x 10^{-4} m/hr

Other Solubilities: Soluble in xylene (24.7%), toluene (27.6%), petroleum ether (2.9%), ethyl acetate (35.7%), carbon tetrachloride (6.7%), cyclohexanone (36.7%), acetic acid (12.8%), dioxane (31.4%); lindane solubility per 100 g/solvent: acetone (43.5 g), benzene (28.9 g), chloroform (24 g), ether (20.8 g) and ethanol (6.4 g).

Boiling Point: 614 °F (323 °C)

Melting Point: 234.5 °F (112.5 °C)

Refractive Index: 1.644 at 68 °F (20 °C/D)

Section 10 - Stability and Reactivity

Stability: Lindane will slowly decompose at ordinary pH [50% at 72 °F (22 °C), pH 7: 191 days] and more rapidly under alkaline conditions (50% at 22 °C, pH 9: 11 hr).

Polymerization: Hazardous polymerization does not occur.

Chemical Incompatibilities: Lindane is decomposed by alkalis to form trichlorobenzenes and reacts with powdered aluminum, iron, and zinc.

Conditions to Avoid: Exposure to incompatibles.

Hazardous Decomposition Products: Thermal oxidative decomposition of lindane can produce carbon oxides, chlorine, hydrogen chloride, and phosgene gas.

Section 11- Toxicological Information

Toxicity Data:*

Acute Oral Effects:

Child, oral, TD_{Lo}: 180 mg/kg caused convulsions or effect on seizure threshold, difficulty breathing, and cyanosis (blue-tinged skin, lips and fingernails due to a decrease in oxygenated blood).

Rat, oral, LD_{50}: 76 mg/kg

Acute Dermal Toxicity:

Man, skin, TD_{Lo}: 20 mg/kg applied intermittently for 6 weeks caused visual field and cardiac changes.

Rat, skin, LD_{50}: 414 mg/kg

Carcinogenicity:

Mouse, oral: 14 g/kg administered continuously for 2 years produced liver tumors.

Mouse, oral: 25 g/kg administered continuously for 73 weeks produced lung and liver tumors.

Mutagenicity:

Rat, liver cell: 30 µmol/L caused DNA damage.

Human, fibroblast: 100 mg/kg caused mutation.

Reproductive Effects:

Woman, oral: 5 mg/kg taken during the 18th week of pregnancy resulted in fetal death.

* See NIOSH, *RTECS* (GV4900000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Coho salmon, LC_{50} = 23 µg/L/96 hr; mallard duck, oral, LD_{50} = > 2000 mg/kg; rainbow trout, LC_{50} = 27 µg/L/96 hr; fathead minnow, LC_{50} = 87 µg/L/96 hr.

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Environmental Degradation: Lindane is more persistent in dry, sandy soils than in moist soils. 50 to 90% of lindane applied to moist soil was lost in 6 hr and 6 days, respectively. Only 12% was lost from dry soil in 50 hr. In general, lindane applied to soil will mostly volatilize while some will slowly leach to groundwater. If released to water, lindane will mostly diffuse into sediment. If water is alkaline, hydrolysis may occur. Lindane will bioconcentrate in some aquatic organisms. In the atmosphere, lindane will react with hydroxyl radicals (half-life: 1.63 days). It will also be removed by rainfall and dry deposition. Average residence time in the atmosphere is 17 weeks.

Section 13 - Disposal Considerations

Disposal: Lindane is a potential candidate for liquid injection or rotary kiln incineration. Biodegradation should be investigated as lindane may be decomposed by sludge flora or blue-green algae. Chemical processes appear to be of little use, as degradation products may be even more harmful than lindane itself. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Organochlorine pesticides, solid, toxic, n.o.s.
Shipping Symbols: –
Hazard Class: 6.1
ID No.: UN2761
Packing Group: III
Label: Keep Away From Food
Special Provisions (172.102): –

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.213
c) Bulk Packaging: 173.240

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 100 kg
b) Cargo Aircraft Only: 200 kg

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U129
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); and CWA, Sec. 307(a)
CERCLA Reportable Quantity (RQ), 1 lb (0.454 kg)
SARA 311/312 Codes: 1, 2
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a SARA EHS (Extremely Hazardous Substance) (40 CFR 355), Threshold Planning Quantity (TPQ): 1,000/10,000 lb*
OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

*The lower TPQ applies to solids in powder form with a particle size of < 100 microns; in molten or solution form; or meets the NFPA rating of 2, 3, or 4 for reactivity. If the solid does not meet any of these criteria, the higher TPQ applies.

Section 16 - Other Information

References: 73, 103, 124, 132, 133, 136, 148, 153, 167, 168, 169, 176, 187, 190

Prepared By ..... M Gannon, BA
Industrial Hygiene Review ..... PA Roy, MPH, CIH
Medical Review ..... W Silverman, MD

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Material Safety Data Sheets Collection

Dichloroethyl Ether

MSDS No. 571

Date of Preparation: 1/86 Revision: A, 10/93

Section 1 - Chemical Product and Company Identification 42

Product/Chemical Name: Dichloroethyl Ether
Chemical Formula: $(ClCH_2CH_2)_2O$
CAS No.: 111-44-4
Synonyms: bis (2-chloroethyl) ether; Chlorex; 1-chloro-2-(beta-chloroethoxy) ethane; DCEE; 2,2'-dichlorodiethyl ether; sym-dichloroethyl ether; dichloroethyl oxide; 1,1'-oxybis (2-chloro) ethane.
Derivation: Produced by chlorination of ethyl ether or treating ethylene chlorohydrin with sulfuric acid.
General Use: As a reagent for organic synthesis; solvent for cellulose esters, naphthalenes, oils, fats, greases, pectin, tar, and gum; scouring agent for textiles; soil fumigant; in fulling compounds and dry cleaning.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Dichloroethyl ether, 100 % vol

OSHA PELs
Ceiling: 15 ppm (90 mg/m^3), *skin*
8-hr TWA: 5 ppm (30 mg/m^3), *skin* *
STEL: 10 ppm (60 mg/m^3) *

ACGIH TLVs
TWA: 5 ppm (29 mg/m^3), *skin*
STEL: 10 ppm (58 mg/m^3), *skin*

NIOSH REL
10-hr TWA: 5 ppm (30 mg/m^3), *skin*
STEL: 10 ppm (60 mg/m^3)

IDLH Level
250 ppm (mg/m^3)

DFG (Germany) MAK
TWA: 10 ppm (60 mg/m^3), *skin*
Category II: Substances with systemic effects
Onset of effect: > 2 h
Half-life: 2 h to shift length

Peak Exposure Limit:
50 ppm, 30 min. average value, 2/shift.

*Vacated 1989 Final Rule Limits

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Dichloroethyl ether is a colorless liquid with a pungent, fruity odor. It is very irritating to the eyes and respiratory tract. It is a strong sensitizer and may cause a severe allergic respiratory response. Inhalation of high concentrations may cause central nervous system (CNS) depression. Liver and kidney injury is possible. It is combustible and forms unstable peroxides upon standing.

Wilson Risk Scale	
R	1
I	3
S	2*
K	2

*Skin absorption

HMIS	
H	3
F	2
R	1

PPE† †Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, eye contact, skin absorption.
Target Organs: Eyes, CNS, respiratory tract; kidney and liver (possibly, as yet only seen in animals).
Acute Effects
Inhalation: Symptoms include coughing, respiratory tract irritation, nausea, and vomiting. Unconsciousness has occurred from animal exposure to high concentrations and is expected in humans. Pulmonary edema may also occur. Volunteers found exposure to 35 ppm non-irritating but the odor was noticeable; 100 to 260 ppm was irritating but not intolerable; and > 500 ppm was highly irritating and considered intolerable. Exposure to 1000 ppm for 30 to 60 minutes can cause death within a few days due to delayed respiratory lesions.
Eye: Direct eye contact with liquid or vapor is highly irritating and causes watering.
Skin: Skin contact with the pure liquid is not irritating but it is absorbed readily and may cause systemic effects.
Ingestion: Effects not specified.
Carcinogenicity: The following agencies have classified dichloroethyl ether's carcinogenicity: IARC (Class 3, not classifiable as to carcinogenicity), NIOSH (Class X, carcinogen defined without further designation), and EPA (Class B2, probable human carcinogen).
Medical Conditions Aggravated by Long-Term Exposure: Respiratory, central nervous system, liver, or kidney disorders.
Chronic Effects: Possible mild bronchitis from repeated exposure. Sensitized individuals may have a severe allergic reaction.
Other: Minimum lethal exposure is estimated at 50 to 500 mg/kg. Skin absorption is more hazardous because inhalation is limited by low volatility. Also, concentrations needed to cause respiratory tract damage are easily detectable by odor and generally intolerable.

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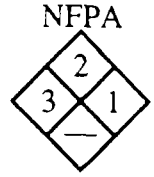
Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed.
Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Notes to Physicians: Treatment is symptomatic and supportive. Observe for delayed breathing difficulties after heavy exposure. A chest X-ray is advisable for significant exposures. Liver and kidney function tests may also be indicated.

Section 5 - Fire-Fighting Measures



Flash Point: 131 °F (55 °C)
Flash Point Method: CC
Burning Rate: 2.4 mm/min.
Autoignition Temperature: 696 °F (368.8 °C)
LEL: 2.7 % v/v
UEL: None reported.
Flammability Classification: Class IIIA Combustible Liquid.
Extinguishing Media: Use dry chemical, water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: Container may explode in heat of fire.
Hazardous Combustion Products: Include carbon oxides, phosgene, and hydrogen chloride gases.
Fire-Fighting Instructions: If possible without risk, move containers from fire area. Fight fire from maximum distance. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.
Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is not effective for fires involving dichloroethyl ether.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. Cleanup personnel should protect against exposure. Use water spray to reduce and cool vapors.
Small Spills: Absorb on paper towels and evaporate in a fume hood. Burn paper.
Large Spills
Containment: For large spills, dike far ahead of liquid spill for later disposal. Do not release into sewers or waterways.
Cleanup: Reclaim large quantities.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Use non-sparking tools to open containers.
Storage Requirements: Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles. Storage of small quantities is preferred to avoid the formation of peroxides when containers are frequently open and closed. Install Class I, Group Undesignated.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: To prevent static sparks, electrically ground and bond all equipment used with and around dichloroethyl ether.
Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103)
Administrative Controls: Consider preplacement and periodic medical exams with emphasis on the respiratory tract, liver, and kidney.
Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use any supplied-air respirator or SCBA with a full facepiece and operated in pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

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Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets made of chlorinated polyethylene or Teflon to prevent prolonged or repeated skin contact. *Do not* use butyl rubber. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove dichloroethyl ether from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using dichloroethyl ether, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Liquid

Appearance and Odor: Colorless with a pungent, fruity odor.

Odor Threshold: 35 ppm

Vapor Pressure: 0.4 mm Hg at 68 °F (20 °C)

Formula Weight: 143.02

Density: 1.2220 g/L at 68 °F (20 °C)

Water Solubility : 102 ppm at 77 °F (25 °C)

Octanol/Water Partition Coefficient: log Kow = 1.58 (calculated)

Other Solubilities: Soluble in alcohol, acetone, benzene, and ether. Also in aromatic but not paraffin hydrocarbons. It dissolves oils, greases, and fats.

Boiling Point: 353.3 °F (178.5 °C)

Freezing Point: -61.24 °F (-51.8 °C)

Viscosity: 2.0653 cP at 77 °F (25 °C)

Refraction Index: 1.457 at 68 °F (20 °C)

Surface Tension: 37.9 dyne/cm at 66.2 °F (19 °C)

Bulk Density: 10.2 lb/gal at 68 °F (20 °C)

Section 10 - Stability and Reactivity

Stability: Dichloroethyl ether forms unstable peroxides when exposed to air.

Polymerization: Hazardous polymerization does not occur. Inhibitors usually added to prevent peroxide formation.

Chemical Incompatibilities: Include oxidizers, chlorosulfonic acid, fuming sulfuric acid, and other strong acids. It will attack some forms of plastics, rubber, and coatings. Decomposes in moist air to form hydrochloric acid.

Conditions to Avoid: Exposure to heat, ignition sources, sunlight, incompatibles and prolonged exposure to air (forms peroxides).

Hazardous Decomposition Products: Thermal oxidative decomposition of dichloroethyl ether can produce carbon oxides, phosgene, and hydrogen chloride gases.

Section 11- Toxicological Information

Toxicity Data:*

Eye Effects:
Rabbit, eye: 100 mg caused severe irritation.

Skin Effects:
Rabbit, skin (open patch test): 500 mg caused mild irritation.

Carcinogenicity:
Mouse, oral: 33 g/kg for 79 continuous weeks caused liver and blood tumors, including Hodgkin's disease.

Acute Inhalation Effects:
Rat, inhalation, LC_{50}: 330 mg/m^3/4 h; details not reported.

Acute Oral Effects:
Rat, oral, LD_{50}: 75 mg/kg; details not reported
Mouse, oral, LD_{50}: 209 mg/kg caused drooping of upper eyelids, changes in the salivary glands, diarrhea, and hypermotility.

* See NIOSH, *RTECS* (KN0875000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Daphnia magna, EC_{50} = 238,000 mcg/L/48 h.

Environmental Degradation: In water, dichloroethyl ether will undergo hydrolysis with a half-life of 20 yr at 77 °F (25 °C). It has a volatilization half-life of 3.5, 4.4, and 180.5 days in streams, rivers, and lakes, respectively. It is highly mobile in soil and rapidly leaches to groundwater. It has a hydrolysis half-life in soil of 40 days at pH 7. In the air it reacts with photochemically produced hydroxyl radicals with a half-life of 13.44 hr.

Section 13- Disposal Considerations

Disposal: Dichloroethyl ether is a potential candidate for rotary kiln, liquid injection, and fluidized-bed incineration. An acid-scrubber is needed to remove the halo-acids produced. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Container Cleaning and Disposal: Triple rinse containers and dispose of rinse water as any other dichloroethyl ether waste.

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Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: 2,2-Dichlorodiethyl Ether
Shipping Symbols: –
Hazard Class: 6.1
ID No.: UN1916
Packing Group: II
Label: Poison, Flammable liquid
Special Provisions (172.102): N33, N34, T8

Packaging Authorizations
a) **Exceptions:** None
b) **Non-bulk Packaging:** 173.202
c) **Bulk Packaging:** 173.243

Quantity Limitations
a) **Passenger, Aircraft, or Railcar:** 5 L
b) **Cargo Aircraft Only:** 60 L

Vessel Stowage Requirements
a) **Vessel Stowage:** A
b) **Other:** –

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste Number (40 CFR 261.33): U025
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per RCRA, Sec. 3001 and CWA, Sec. 307(a).
CERCLA Reportable Quantity (RQ), 10 lb (4.54 kg)
SARA 311/312 Codes: 2, 3
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a SARA EHS (Extremely Hazardous Substance) (40 CFR 355), Threshold Planning Quantity (TPQ): 10,000 lb
OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 26, 73, 100, 103, 124, 126, 127, 132, 133, 136, 148, 153, 159, 167, 168, 176, 183

Prepared By ..... M Gannon, BA
Industrial Hygiene Review ..... PA Roy, MPH, CIH
Medical Review ..... T Thoburn, MD, MPH

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 606

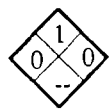
OLEIC ACID

Issued: March 1987

SECTION 1. MATERIAL IDENTIFICATION

22

MATERIAL NAME: OLEIC ACID



DESCRIPTION/USES: A nonsaturated fatty acid that occurs in the form of glycerides in vegetable oils and animal fats and oils. Used in making textile soaps, synthetic detergents, lubricants, sulfonated oils and cosmetics, and in compounding rubber.

OTHER DESIGNATIONS: 9-Octadecenoic Acid, Red Oil, $C_{17}H_{33}COOH$; CAS #0112-80-1.

MANUFACTURER/SUPPLIER: Emery Chemicals, 11501 Northlake Drive, PO Box 429557, Cincinnati, OH 45249; Telephone: 800-543-7370; 800-582-7051 (OH)

HMIS	
H 0	
F 1	R 1
R 0	I ---
PPE*	S 1
*See Sect. 8	K 1

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Oleic Acid, CAS #0112-80-1	100	No TLV Established Rat, Oral, LD_{50}: 74 gm/kg Human, Skin, 15 mg/3 Days: Intermittent (Moderate Irritation)
See the Merck Index (our Reference 5) for the chemical structure of this material.		

SECTION 3. PHYSICAL DATA

Boiling Point, 1 atm, Decomposes ... 680°F (359.7°C)
Vapor Pressure @ 180°C, mm Hg ... 1.0
Water Solubility ... Not Soluble
Vapor Density (Air = 1) ... 9.7
Evaporation Rate ... Not Found

Specific Gravity (H_2O = 1) ... 0.895
Melting Point ... 61.4°F (16.3°C)
Percent Volatile by Volume ... Not Volatile
Molecular Weight ... 282.5

Appearance and odor: Pale yellow-to-red oily liquid; characteristic fatty-acid odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
365°F (185°C) COC	685°F (362°C)	None Found	—	—

EXTINGUISHING MEDIA: Put out an oleic acid fire with a dry chemical, carbon dioxide, or foam. A water spray can be used to cool containers that are exposed to fire to prevent their rupturing from pressure.
UNUSUAL FIRE/EXPLOSION HAZARDS: Not found.
SPECIAL FIRE-FIGHTING PROCEDURES: Oleic acid is an OSHA class III B combustible liquid. Water or foam may cause frothing if directed into a container of the burning liquid.
Fire fighters should use self-contained breathing apparatus and wear fully protective clothing.

SECTION 5. REACTIVITY DATA

Oleic acid is stable. Hazardous polymerization cannot occur.

Chemical incompatibilities include oxidizing agents.

Avoid exposing this material to excessive heat or open flame. Keep its containers closed to avoid exposure to air and prevent rancidity. Oleic acid decomposes at 176 to 212°F (80 to 100°C).

Products of hazardous decomposition of this material can include oxides of carbon and acrid vapors.

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SECTION 6. HEALTH HAZARD INFORMATION

Oleic acid is not listed as a carcinogen by the NTP, IARC, or OSHA.
This material is not expected to be hazardous. Avoid excessive inhalation of its mist or fume that is generated on heating.
Oleic acid's prolonged or repeated contact with skin may cause irritation.
TARGET ORGANS: Skin. PRIMARY ENTRY: Inhalation. ACUTE EFFECTS: Skin irritation.
CHRONIC EFFECTS: None found.

FIRST AID: EYE CONTACT: Flush eyes thoroughly with running water, including under the eyelids, for 15 minutes.
SKIN CONTACT: Remove contaminated clothing. Flush affected area with water; wash with soap and water.
INHALATION: Remove victim to fresh air. Restore and/or support his breathing as required. Get medical help.*
INGESTION: Get medical help.*

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Notify safety personnel of oleic acid spills. Provide adequate ventilation. Remove sources of heat or ignition. Cleanup personnel should use protection against contact with liquid or inhalation of mist. Contain spill and scoop up waste material for recovery or disposal. Absorb small spills and residues with sand or vermiculite or other suitable absorbant materials. Place absorbed material into a covered metal container for disposal. Oleic acid can be converted to water-soluble soap with the addition of sodium carbonate.

Reclaim uncontaminated material for salvage or reuse. Unsalvageable material is biodegradable and can be buried in an approved landfill.

EPA, Clean Water Act, Reportable Spill Quantity: Not Found.

SECTION 8. SPECIAL PROTECTION INFORMATION

Use a NIOSH-approved respirator for emergencies or when concentrations of oleic acid vapor are unknown.

Provide general ventilation in areas of use and storage. Local exhaust ventilation may be needed when oleic acid is heated or misted.

Wear neoprene rubber gloves and other additional protective clothing suitable for use conditions to prevent prolonged or repeated skin contact. Wear chemical safety goggles for eye protection where misty conditions occur. Remove soiled work clothing and launder it before wearing it again.

Eyewash stations and washing facilities should be accessible to areas of use and handling.

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

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store oleic acid in tightly closed containers in a clean, dry, well-ventilated area away from sources of heat, light, or open flame. Protect containers from physical damage.

Keep containers tightly closed. Oleic acid slowly absorbs oxygen from the air and will darken upon exposure.

Minimize oleic acid's prolonged or repeated contact with skin by wearing proper work clothing.

Oleic acid is not designated as a hazardous substance by the EPA (40 CFR 116).
DOT Classification: Not Found DOT ID No. Not Found
Data Source(s) Code: 1, 4-7, 10, 34, 45, 83, 84. CK

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Approvals	
Indust. Hygiene/Safety	5/87
Medical Review	May 87

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GENIUM PUBLISHING CORP.

No. 624

NAPHTHALENE

Issued: November 1987

SECTION 1. MATERIAL IDENTIFICATION

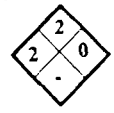
24

Material Name: NAPHTHALENE

Description (Origin/Uses): Used as a moth repellant and in many industrial processes.

Other Designations: Naphthalin; Naphthene; Tar Camphor; $C_{10}H_8$; NIOSH *RTECS* No. QJ0525000; CAS No. 0091-20-3

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



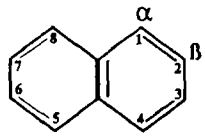
HMIS
H 2
F 2
R 0
PPG*
*See sect. 8

R 1
I 4
S 1
K 2

SECTION 2. INGREDIENTS AND HAZARDS

%	EXPOSURE LIMITS
ca 100	IDLH* Level: 500 ppm **ACGIH TLVs, 1987-88** TLV-TWA: 10 ppm, 50 mg/m³ **OSHA PEL** 8-Hr TWA: 10 ppm, 50 mg/m³ **Toxicity Data**** Child, Oral, LD_{Lo}: 100 mg/kg Man, Unknown, LD_{Lo}: 74 mg/kg Rat, Oral, LD_{50}: 1250 mg/kg

Naphthalene, CAS No. 0091-20-3



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

SECTION 3. PHYSICAL DATA

Boiling Point: 424°F (218°C)
Vapor Density (Air = 1): 4.4
Vapor Pressure: 0.087 Torr at 77°F (25°C)
Water Solubility: Insoluble

Specific Gravity (H_2O = 1): 1.162 at 68°F (20°C)
Melting Point: 176°F (80°C)
Molecular Weight: 128 Grams/Mole
% Volatile by Volume: ca 100

Appearance and Odor: White crystalline flakes; strong coal tar odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
		% by Volume		
174°F (79°C) OC; 190°F (88°C) CC	979°F (526°C)		0.9	5.9

Extinguishing Media: Use water spray, dry chemical, or carbon dioxide to fight fires involving naphthalene. **Caution:** Foam or direct water spray applied to molten naphthalene may cause extensive foaming.

Unusual Fire or Explosion Hazards: Naphthalene is a volatile solid that gives off flammable vapor when heated (as in fire situations). This vapor is much denser than air and will collect in enclosed or low-lying areas like sumps. In these areas an explosive air-vapor mixture may form, and extra caution is required to prevent any ignition sources from starting an explosion or fire.

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 5. REACTIVITY DATA

Naphthalene is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization.

Chemical Incompatibilities: Naphthalene is incompatible with strong oxidizing agents, chromic anhydride, and mixtures of aluminum trichloride and benzoyl chloride.

Conditions to Avoid: Ignition sources like open flame, unprotected heaters, excessive heat, lighted tobacco products, and electric sparks must not occur in work areas where naphthalene vapor may become concentrated.

Hazardous Products of Decomposition: Toxic gases like carbon monoxide are produced during fire conditions. Irritating, flammable vapor forms below the melting point because even solid naphthalene has a significant vapor pressure.

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SECTION 6. HEALTH HAZARD INFORMATION

Naphthalene is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: Renal shutdown (kidney failure), hemolytic effects (breakdown of red blood cells), hematuria (blood in the urine), oliguria (low volume of urine), jaundice, eye damage, and depression of the central nervous system (CNS) are the primary health concerns associated with exposure to naphthalene. The ACGIH TLVs in section 2 are set to prevent eye damage. These recommended exposure limits may not be low enough to prevent blood changes in genetically hypersensitive individuals.
Medical Conditions Aggravated by Long-Term Exposure: Diseases of the blood, liver, and kidneys. Administer medical exams emphasizing these organs. **Target Organs:** Eyes, skin, kidneys, liver, blood (red blood cell effects), and CNS.
Primary Entry: Inhalation, skin contact. **Acute Effects:** Inhalation of naphthalene vapor causes excitement, confusion, headache, nausea, and loss of appetite. **Chronic Effects:** Increased incidence of cataracts.
FIRST AID
Eye Contact: Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes to remove particles.
Skin Contact: Immediately wash the affected area with soap and water.
Inhalation: Remove victim to fresh air; restore and/or support his breathing as needed.
Ingestion: Call a poison control center. Never give anything by mouth to someone who is unconscious or convulsing. Administer a gastric lavage followed by saline catharsis. Monitor blood and electrolytic balance. Other sources recommend giving the victim several glasses of water to drink.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, provide ventilation, and eliminate all ignition sources immediately. Cleanup personnel need protection against contact and inhalation of vapor (see sect. 8). Contain large spills and collect waste. Use nonsparking tools to place naphthalene into closable containers for disposal. Keep waste out of sewers, watersheds, and waterways.
Waste Disposal: Consider reclamation, recycling, or destruction rather than disposal in a landfill. 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. U165
CERCLA Hazardous Substance, Reportable Quantity: 100 lbs (45.4 kg)

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Follow the eye- and face-protection guidelines of 29 CFR 1910.133. **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. Respirator usage must be in accordance with the OSHA regulations of 29 CFR 1910.134. IDLH or unknown concentrations require 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 Equipment: Wear impervious gloves, boots, aprons, gauntlets, etc., as required by the specific work environment to prevent skin contact. **Ventilation:** Install and operate general and local maximum explosion-proof ventilation systems of sufficient power to maintain airborne levels of naphthalene below the OSHA PEL standard cited in section 2. **Safety Stations:** Make eyewash stations, washing facilities, and safety showers available in areas of use and handling. **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 and launder contaminated clothing before wearing it again; clean this material from shoes and equipment.
Comments: Practice good personal hygiene; always wash thoroughly after using this material. Keep this material off of your clothing and equipment. Avoid transferring this material from hands to mouth while eating, drinking, or smoking. Do *not* smoke, eat, or drink in any immediate work area. Avoid inhalation of vapor!

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store naphthalene in a cool, dry, well-ventilated area away from chemical incompatibles (see sect. 5).
Special Handling/Storage: Protect containers from physical damage. All bulk storage facilities must be built with an explosion-proof design. All containers used in shipping/transferring operations must be electrically grounded to prevent static sparks. Use monitoring equipment to measure the extent of vapor present in any storage facility containing naphthalene because of potential fire and explosion hazards.
Comments: All operations with naphthalene must be done carefully to prevent accidental ignition of its flammable/explosive vapor. If the weather is warm, more naphthalene vapor forms and the potential for explosion increases. Do *not* smoke in any use or storage area!
Transportation Data (49 CFR 172.101-2)
DOT Shipping Name: Naphthalene
DOT Hazard Class: ORM-A
IMO Class: 4.1
DOT ID No. UN1334
IMO Label: Flammable Solid
DOT Label: None

References: 1, 2, 12, 73, 84-94, 103. PJI

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Approvals
Indust. Hygiene/Safety
Medical Review

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GENIUM PUBLISHING CORP.

No. 625

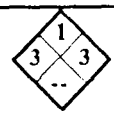
p-NITROANILINE

Issued: November 1987

SECTION 1. MATERIAL IDENTIFICATION

24

Material Name: *p*-NITROANILINE



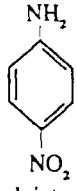
Description (Origin/Uses): This material is used as an intermediate in the manufacture of dyes, antioxidants, pharmaceuticals, and pesticides.

Other Designations: *p*-Aminonitrobenzene; 1-Amino-4-Nitrobenzene; 4-Nitroaniline; 4-Nitrobenzenamine; *p*-Nitrophenylamine; $C_6H_6N_2O_2$; NIOSH *RTECS* No. BY7000000; CAS No. 0100-01-6

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

HMIS	
H 3	
F 1	R 1
R 3	I 4
PPG*	S 3
*See sect. 8	K 1

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
p-Nitroaniline, CAS No. 0100-01-6 	100	**ACGIH TLV (Skin*), 1987-88** TLV-TWA: 3 mg/m³ **OSHA PEL (Skin*)** 8-Hr TWA: 1 ppm, 6 mg/m³ IDLH** Level: 300 mg/m³ **Toxicity Data***** Rat, Oral, LD_{50}: 750 mg/kg Mouse, Oral, LD_{50}: 810 mg/kg

*This material can be absorbed through intact skin, which contributes to overall exposure.
**Immediately dangerous to life and health
***See NIOSH *RTECS* for additional data with references to mutagenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 637°F (336°C)
Vapor Pressure at 20°C, mmHg: 0.00015
Water Solubility at 18.5, wt. %: 0.08
Vapor Density (Air = 1): 4.77
Specific Gravity (H_2O = 1): 1.44
Melting Point: 293°F (146°C)
% Volatile by Volume: ca 100%
Molecular Weight: 138.14 Grams/Mole

Appearance and Odor: Bright yellow crystals or powder; pungent, faint, ammonialike odor.

Comments: *p*-Nitroaniline is not soluble in water, but it is dissolved by alcohol and ether.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
390°F (199°C)	940°F (504°C)	% by Volume	Not Listed	Not Listed

Extinguishing Media: Use carbon dioxide, dry chemical, foam, or water fog. Water or foam may cause frothing. Use water spray to cool fire-exposed tanks/containers.

Unusual Fire/Explosion Hazards: This OSHA class IIIB combustible liquid is a slight fire hazard when exposed to heat, sparks, or open flame. **Warning:** In the presence of moisture it causes nitration (reacting with the NO_2 molecular group) of organic materials resulting in spontaneous ignition. Like many organic materials in powder form, *p*-nitroaniline is capable of creating a dust explosion (refer to NFPA pamphlet No. 63, "Prevention of Dust Explosions in Industrial Plants"). When involved in a fire, *p*-nitroaniline emits toxic fumes of nitrogen oxides.

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 5. REACTIVITY DATA

p-Nitroaniline is stable. Hazardous polymerization cannot occur.

Chemical Incompatibilities: *p*-Nitroaniline is incompatible with strong oxidizing agents and moisture. The liquid will attack some forms of plastics, rubber, and coatings, so care is needed in the selection of safety and handling equipment such as respirators.

Hazardous Products of Decomposition: Thermal decomposition or burning produces oxides of nitrogen, carbon monoxide, and/or carbon dioxide.

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SECTION 6. HEALTH HAZARD INFORMATION

p-Nitroaniline is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: This material is toxic by ingestion, inhalation, and skin absorption. Overexposure by these routes may cause hypoxia (reduced level of oxygen in the blood) because of methemoglobinemia. Symptoms of exposure may include headache, cyanosis, weakness, dizziness, irritability, drowsiness, and dyspnea (shortness of breath) because of methemoglobinemia. Severe exposure may cause unconsciousness and death. **Warning:** Symptoms may not appear until up to 4 hours after exposure. Contact with eyes causes corneal damage. **Medical Conditions Aggravated by Long-Term Exposure:** Workers with liver or kidney diseases should not be exposed to this material. Administer preplacement and annual medical exams emphasizing these organs' functions. **Target Organs:** Blood, heart, lungs, liver. **Primary Entry:** Inhalation, skin contact and absorption, eye contact.

Acute Effects: Headache, eye and skin irritation, blue coloration of skin and lips (cyanosis), nausea and vomiting, muscular weakness, irritability and convulsions, increased pulse and respiratory rate. Smokers may be at increased risk of cyanosis because of a preexisting exposure to tobacco smoke. **Chronic Effects:** Possible liver damage.

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 because of the increased exposure hazard from absorption. **Inhalation:** Remove victim to fresh air; restore and/or support his breathing as required. Keep him warm and quiet. **Ingestion:** Call a poison control center. Never give anything by mouth to someone who is unconscious or convulsing. If victim is responsive, give him an emetic such as two tablespoons of salt in a glass of warm water. Other sources recommend giving the victim several glasses of water to drink.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel of large spills or leaks. Remove all sources of heat and ignition. Provide maximum explosion-proof ventilation. Evacuate the spill area and limit access to necessary personnel only. Remove leaking container to a safe place if it is safe to do so. Those involved in cleanup need protection against contact with the solid and inhalation of dust or vapor (see sect. 8). Shovel, scoop, or vacuum spilled material into a closable container for disposal. Use caution to avoid generating dust. After cleanup wash the spill area with soap and water and collect flushings and wastewater for disposal. Keep waste out of sewers, watersheds, and waterways. Preplan for emergency response. **Waste Disposal:** Consider reclamation, recycling, or destruction rather than disposal in a landfill. 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. U138

CERCLA Hazardous Substance, Reportable Quantity: 5000 lbs (2270 kg)

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. **Gloves:** Always wear impervious gloves.

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. IDLH or unknown concentrations require 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 Equipment:** Make face shields, aprons, boots, and other appropriate protective clothing and equipment available; wear these when necessary to prevent skin contact. **Ventilation:** Install and operate general and local exhaust ventilation systems of sufficient power to maintain airborne levels of *p*-nitroaniline below the OSHA PEL standard cited in section 2. **Safety Stations:** Make eyewash stations and safety showers available in areas of use and handling.

Contaminated Equipment: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Particles may cling to contact lenses and cause corneal injury. Do *not* wear contact lenses in any work areas. Remove and launder contaminated clothing before wearing it again; clean material from shoes and equipment.

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

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store *p*-nitroaniline away from moisture and strong oxidizing agents.

Special Handling/Storage: Store this material in a cool, dry, well-ventilated area away from sources of heat and ignition. Avoid exposure to moist air. Protect containers from physical damage.

Engineering Controls in the Workplace: Ground and bond conveying equipment and storage containers when transferring *p*-nitroaniline to prevent the possibility of a dust explosion. Any bulk storage system should have an explosion-relief design. Moisture contamination of storage facilities must be prevented. If applicable, consider storing this material under a nitrogen blanket.

Other Precautions: Practice good industrial hygiene when handling this material. Avoid generating dust. Emptied containers retain product residues; handle them accordingly! Use extreme caution when using this material. Avoid its contact with skin, eyes, or clothing. Do *not* taste or inhale it!

Transportation Data (49 CFR 172.101-2)

DOT Hazard Class: Poison B	**DOT Shipping Name:** Nitroaniline	**DOT ID No.** UN1661
DOT Label: Poison	**IMO Label:** Poison	**IMO Class:** 6.1

References: 1, 2, 4, 5, 7, 8, 9, 12, 25, 34, 37, 38, 54, 63, 69, 73, 75, 81, 82, 87-94. CR/PJI

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Approvals

Indust. Hygiene/Safety 5/53

Medical Review

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GENIUM PUBLISHING CORP.

No. 628

HEXACHLOROETHANE

Issued: November 1987

SECTION 1. MATERIAL IDENTIFICATION

24

Material Name: HEXACHLOROETHANE

Description (Origin/Uses): Used as a rubber vulcanizing accelerator, as a camphor substitute in celluloids, and in explosives.

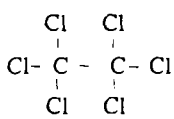
Other Designations: Carbon Hexachloride; Ethane Hexachloride; Ethylene Hexachloride; 1,1,1,2,2,2-Hexachloroethane; Hexachloroethylene; Perchloroethane; C_2Cl_6; NIOSH *RTECS* No. KI4025000; CAS No. 0067-72-1

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

HMIS	
H	1
F	0
R	0
PPG*	
*See sect. 8	
R	1
I	4
S	1
K	0

SECTION 2. INGREDIENTS AND HAZARDS

Hexachloroethane, CAS No. 0067-72-1



NCI Carcinogenesis Bioassay Completed; Results Positive: Mouse (NCITR NCI-CG-TR-68, 78)
NCI Carcinogenesis Bioassay Completed; Results Negative: Rat (NCITR NCI-CG-TR-68, 78)
Carcinogenic Review by IARC 20, 467, 79: Animal Suspect

*This material can be absorbed through intact skin, which contributes to overall exposure.
**Consult NIOSH, *RTECS*, for additional data on reproductive and tumorigenic effects.
***Immediately dangerous to life and health. The ACGIH has proposed a TLV-TWA of 1 ppm, ≈ 10 mg/m³.

%
98

EXPOSURE LIMITS

ACGIH TLVs, 1987-88
TLV-TWA: 10 ppm, ≈100 mg/m³

OSHA PEL (Skin*)
8-Hr TWA: 1 ppm, 10 mg/m³

Toxicity Data**
Rat, Oral, LD_{50}: 6000 mg/kg
Mouse, Intraperitoneal, LD_{50}: 4500 mg/kg

IDLH*** Level: 300 ppm

SECTION 3. PHYSICAL DATA

Vapor Pressure, 20°C mm Hg: 0.22
Water Solubility: 0.005 g/100 ml water
Vapor Density (Air = 1): >1
Evaporation Rate (BuAc = 1): 0.6
Specific Gravity: 2.09 at 68°F (20°C)

Appearance and Odor: Clear, colorless liquid; mild gasolinelike odor.

Comments: Hexachloroethane sublimes directly without melting at 368.2°F (186.8°C). The saturated air concentration is approximately 670 to 700 ppm at 68°F (20°C). It is soluble in alcohol, toluene, benzene, chloroform, oil, and ether.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
Nonflammable	Nonflammable	% by Volume	Not Applicable	Not Applicable

Extinguishing Media: If it can be done without risk, remove material from fire area. Hexachloroethane does not burn. Use a dry chemical, carbon dioxide, alcohol foam, water spray, or other appropriate extinguishing agent suitable for the surrounding fire. Use a water spray to cool fire-exposed containers, to flush spills away from exposures, and to protect men attempting to remove hexachloroethane from the fire area.

Unusual Fire/Explosion Hazards: Hexachloroethane vapor is denser than air and can flow along surfaces to low-lying areas where it may become concentrated.

Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective gear.

SECTION 5. REACTIVITY DATA

Hexachloroethane is stable. Hazardous polymerization cannot occur.

Chemical Incompatibilities: This material is incompatible with strong oxidizing agents. Avoid reaction with strong alkalies and metals (hot iron, zinc, aluminum) that will produce spontaneously explosive chloroacetylenes from dehalogenation.

Conditions to Avoid include elevated temperatures above 328°F (186°C) and direct physical contact with the previously listed chemically incompatible materials.

Hazardous Products of Decomposition can include oxides of carbon, hydrogen chloride gas, and phosgene. Hydrogen chloride and phosgene gases are very toxic, corrosive, and dangerous.

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SECTION 6. HEALTH HAZARD INFORMATION

In the *Current Intelligence Bulletin* of August 1978 (Genium ref. 31), NIOSH recommended that exposures to hexachloroethane be reduced to the lowest feasible level because of its potential as a carcinogen. Hexachloroethane is considered to be carcinogenic by *RTECS* criteria, and it is reported to have caused liver tumors in mice (see NCITR NCI-CG-TR-68, 78).

Summary of Risks: The acute inhalation hazard is expected to be low because of hexachloroethane's low vapor pressure. Exposure to high concentrations has shown narcosis in animals as well as central nervous system depression characterized by weakness, staggering gait, and muscle twitching. This material is irritating to skin and mucous membranes. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Eyes. **Primary Entry:** Inhalation, eye and skin contact.

Acute Effects: Eye irritation. **Chronic Effects:** 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 because of the increased exposure hazard from absorption. **Inhalation.** Remove victim to fresh air; restore and/or support his breathing as needed. **Ingestion.** Call a poison control center. Give victim 2 to 3 glasses of water to drink to dilute the material. Never give anything by mouth to someone who is unconscious or convulsing.

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

Comments: "NIOSH recommends that [hexachloroethane] be treated as a carcinogen" (*Am. Ind. Hyg. Assoc. J.* 40 [March 1979]: A-46). Consider using an alternative chemical; if it is irreplaceable, minimize all possible contact with this material.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel of a hexachloroethane spill or leak and implement containment procedures. Cleanup personnel should use protection against inhalation of vapor. When necessary, contain spills using an absorbent material such as dry sand or vermiculite (avoid raising dust). Mix well and place waste in an appropriate container for disposal. Flush trace residue with a lot of water. Do not flush waste to sewers or open waterways. Preplan for emergency response.

Waste Disposal: Waste may be burned in an approved incinerator equipped with an afterburner and scrubber. Consider reclamation, recycling, or destruction rather than disposal in a landfill. 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. U131

CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg)

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, wear a full faceshield as a supplementary protective measure. **Gloves:** Wear impervious rubber gloves. **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. At any detectable concentration of hexachloroethane NIOSH recommends an SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode. Follow the respirator guidelines in 29 CFR 1910.134. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres.

Ventilation: Install and operate general and local exhaust ventilation systems of sufficient power to maintain airborne levels of hexachloroethane below the legislated OSHA PEL cited in section 2. Local exhaust fume hoods should have a minimum face velocity of 100 lfm (linear feet per minute). A local exhaust ventilation system should be the primary removal system as dispersion of the contaminant into the general work area is eliminated. **Safety Stations:** Make eyewash stations, washing facilities, and safety showers available in areas of use and handling. **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. **Comments:** Practice good personal hygiene. Keep this material off of your clothes and equipment. Avoid transferring this material from hands to mouth while eating, drinking, or smoking. Do *not* smoke, eat, or drink in any immediate work area.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store hexachloroethane in tightly closed containers in a cool, dry, well-ventilated area away from oxidizing agents and sources of heat and ignition. Protect containers from physical damage.

Engineering Controls in the Workplace: Maintain engineering systems and standard operating procedures that minimize contact with this material to the greatest possible extent.

Comments: Do not take hexachloroethane home or out of your work area on your clothes or equipment. Avoid breathing vapors or contact with skin, eyes, or clothing. Wash thoroughly after handling and before eating, drinking, smoking, or using the toilet.

Transportation Data (49 CFR 172.101-2)

DOT Hazard Class: ORM-A **DOT Shipping Name:** Hexachloroethane **DOT ID No.** NA9037

References: 2, 4, 5, 6, 10, 12, 14, 30, 31, 47, 73, 87-94. CK/PJI

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Approvals

Indust. Hygiene/Safety

Medical Review

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GENIUM PUBLISHING CORP.

No. 636

MESITYLENE

Issued: November 1987

SECTION 1. MATERIAL IDENTIFICATION

24

Material Name: MESITYLENE

Description (Origin/Uses): Used as a raw material in chemical synthesis and as an ultraviolet stabilizer.

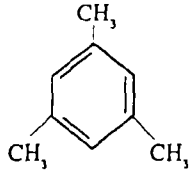
Other Designations: 1,3,5-Trimethylbenzene; 1,3,5-Trimethyl Benzol; TMB; *sym*-Trimethylbenzene; C_9H_{12}; NIOSH *RTECS* No. DC3220000; CAS No. 0108-67-8

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

HMIS	
H 1	
F 2	R 1
R 0	I 3
PPG*	S 2
*See sect. 8	K 2

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
Mesitylene, CAS No. 0108-67-8	ca 100	**ACGIH TLV, 1987-88** TLV-TWA: 25 ppm, 125 mg/m³ **Toxicity Data*** Human, Inhalation, TC_{Lo}: 10 ppm



*See NIOSH, *RTECS*, for additional data.

SECTION 3. PHYSICAL DATA

Boiling Point: 328.3°F (164.6°C)
Vapor Pressure at 20°C, mm Hg: 1.86
Water Solubility: Negligible
Vapor Density (Air = 1): 4.15
Evaporation Rate: Not Found

Specific Gravity (H_2O = 1): 0.8652
Melting Point: -48.6°F (-44.8°C)
% Volatile by Volume: ca 100
Molecular Weight: 120.19 Grams/Mole

Appearance and odor: A clear, colorless liquid; peculiar aromatic odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
112°F (44°C) TCC	970°F (521°C)	% by Volume (Calculated)	1.47%	Not Found

Extinguishing Media: Use dry chemical, foam, carbon dioxide, or water fog. Do not use a solid stream of water because the stream will scatter the fire and spread it. Use water spray to cool fire-exposed tanks/containers and to disperse vapors.

Unusual Fire/Explosion Hazards: This OSHA class II combustible liquid is a moderate fire hazard when exposed to heat, sparks, or open flame. It can react vigorously with oxidizing materials. **Warning:** When mesitylene is heated, its vapors may form explosive mixtures with air.

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 5. REACTIVITY DATA

Mesitylene is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization.

Chemical Incompatibilities: Mesitylene is incompatible with strong oxidizing agents.

Conditions to Avoid: Prevent contact with heat, sparks, and open flame.

Hazardous Products of Decomposition: Thermal decomposition or burning may produce carbon dioxide and/or carbon monoxide.

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SECTION 6. HEALTH HAZARD INFORMATION

Mesitylene is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: Mesitylene vapor is somewhat unpleasant and may cause irritation of the eyes, nose, and throat. Overexposure to high concentrations of vapor may cause narcosis and central nervous system depression. The liquid is irritating to the eyes and may cause irritation of the skin, especially if contact is repeated or prolonged. **Warning:** Aspiration of liquid into lungs can cause chemical pneumonitis.
Medical Conditions Aggravated by Long-Term Exposure: None reported. **Target Organs:** Central nervous system.
Primary Entry: Inhalation, skin and eye contact. **Acute Effects:** Central nervous system depression, skin and eye irritation.
Chronic Effects: 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. **Skin Contact.** Immediately wash the affected area with soap and water. **Inhalation.** Remove victim to fresh air; restore and/or support his breathing as needed.
Ingestion. Call a poison control center. Never give anything by mouth to someone who is unconscious or convulsing. If the victim is responsive, give him one or two glasses of milk or water to drink. Do not induce vomiting because of possible aspiration hazards.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel of large mesitylene spills or leaks. Remove all sources of heat and ignition. Provide maximum explosion-proof ventilation. Evacuate the spill area and limit access to necessary personnel only. Remove leaking containers to a safe place, if feasible. Those involved in cleanup need protection against contact with liquid and inhalation of vapor (see sect. 8). Absorb small spills with paper toweling or vermiculite. Contain large spills and collect them, if feasible, or absorb them with an inert material such as sand, earth, or vermiculite. Place waste liquid or absorbent into closable containers for reclamation or disposal, using nonsparking tools. Water spray may be used to flush spills away from sensitive exposures. Keep waste out of sewers, watersheds, or waterways.

Waste Disposal: Consider reclamation, recycling, or destruction rather than disposal in a landfill. Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. **Gloves:** Wear impervious gloves.
Respirator: Use 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. IDLH or unknown concentrations require an SCBA, full facepiece, and pressure-demand/positive-pressure modes. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Ventilation:** Install and operate ventilation systems of sufficient power to maintain airborne levels of mesitylene below the cited exposure limit set by the ACGIH in section 2.
Safety Stations: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling.
Contaminated Equipment: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Remove and launder contaminated clothing before wearing it again; clean material from shoes and equipment.
Comments: Practice good personal hygiene. Keep material off of your clothing and equipment. Avoid transferring material from hands to mouth while eating, drinking, or smoking.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store mesitylene in closed containers in a cool, dry, well-ventilated area away from oxidizing agents, heat, sparks, and open flame.
Special Handling/Storage: Storage area must meet OSHA requirements for class II combustible liquids. Protect containers from physical damage.
Engineering Controls in the Workplace: All bulk storage facilities must have an explosion-proof design. Ground and bond metal containers and equipment when transferring them to prevent static sparks.
Other Precautions: Do not smoke in areas where this material is handled or stored. Emptied containers retain product residues; handle them accordingly!
Transportation Data (49 CFR 172.101-2)
DOT Shipping Name: 1,3,5-Trimethylbenzene
DOT Hazard Class: Flammable Liquid
IMO Class: 3.3

DOT ID No. UN2325
IMO Label: Flammable Liquid
DOT Label: Flammable Liquid

References: 1, 2, 5, 7, 9, 12, 37, 59, 73, 81, 82, 84-94, 103. CR/PJI

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Medical Review [signature]

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GENIUM PUBLISHING CORP.

No. 648

BROMOFORM

Issued: April 1988

SECTION 1. MATERIAL IDENTIFICATION

25

Material Name: BROMOFORM

Description (Origin/Uses): Used to make high-density liquids for petrographic analysis; used as a chemical intermediate and a solvent.

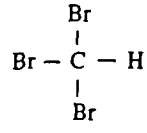
Other Designations: Tribromomethane; $CHBr_3$; NIOSH *RTECS* No. PB5600000; CAS No. 0075-25-2

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

HMIS	
H	2
F	0
R	0
PPG*	
*See sect. 8	
R	1
I	4
S	2
K	0

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
Bromoform, CAS No. 0075-25-2	Ca 100	**OSHA PEL (Skin*)** 8-Hr TWA: 0.5 ppm, 5 mg/m³ **ACGIH TLV (Skin*), 1987-88** TLV-TWA: 0.5 ppm, 5 mg/m³ **Toxicity Data**** Rat, Oral, LD_{50}: 1147 mg/kg Rat, Inhalation, LC_{Lo}: 45 g/m³ (4 Hrs)



*This material can be absorbed through intact skin, which contributes to overall exposure.
**See NIOSH, *RTECS*, for additional data with references to tumorigenic and mutagenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 302°F (150°C)
Melting Point: 48.2°F (9°C)
Water Solubility: Slight

Molecular Weight: 253 Grams/Mole
Vapor Pressure: 5 Torrs at 68°F (20°C)
Specific Gravity (H_2O = 1): 2.89 at 68°F (20°C)

Appearance and Odor: A colorless, heavy liquid; similar to chloroform in odor and taste.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
*	*	% by Volume	*	*

Extinguishing Media: *Bromoform does not burn. Use agents that will put out the surrounding fire.

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 5. REACTIVITY DATA

Bromoform is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization.

Chemical Incompatibilities: This material is incompatible with strong alkalies such as lithium and sodium-potassium alloys.

Conditions to Avoid: Avoid direct contact with incompatible chemicals.

Hazardous Products of Decomposition: When heated to decomposition, bromoform readily emits highly toxic gases such as carbon monoxide (CO), hydrogen bromide (HBr), and oxides of bromine (BrO_x).

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SECTION 6. HEALTH HAZARD INFORMATION

Bromoform is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: Inhalation of bromoform vapor causes irritation of the upper respiratory tract (URT). It can be absorbed through the skin, lungs, and the linings of the gastrointestinal (GI) tract. Possible liver and kidney damage are health concerns associated with this liquid. It depresses the central nervous system (CNS); if the exposure is severe enough, narcosis and coma can occur.
Medical Conditions Aggravated by Long-Term Exposure: Existing problems with the CNS, kidneys, liver, and the lungs may be worsened by exposure to bromoform; administer preplacement and periodic medical exams emphasizing their functions.
Target Organs: CNS, liver, kidneys, lungs, skin, and eyes. **Primary Entry:** Inhalation, skin absorption/contact.
Acute Effects: Irritation of the skin, eyes, and URT; CNS depression. **Chronic Effects:** None reported.
FIRST AID
Eyes: Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes.
Skin: Immediately wash the affected area because of increased hazard from absorption.
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 unless directed to do so by a physician.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate all nonessential personnel, and provide maximum possible ventilation. Cleanup personnel must have protection against contact with and inhalation of vapor (see sect. 8). Clean up bromoform spills with an absorbent such as sand or vermiculite and place waste into containers for disposal.
Waste 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. U225
CERCLA Hazardous Substance, Reportable Quantity: 100 lbs (45.4 kg)

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, consider wearing 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:** Wear impervious gloves, boots, aprons, etc., as required by the specific work environment to prevent skin contact. **Ventilation:** Install and operate general and local ventilation systems that are powerful enough to maintain airborne levels of bromoform below the OSHA PEL standard cited in section 2.
Safety Stations: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling.
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,
Comments: Practice good personal hygiene; always wash thoroughly after using this material. 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 bromoform vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store bromoform in closed containers in a cool, dry, well-ventilated area away from strong alkalies like lithium, sodium, and potassium. Protect these containers from physical damage.

Comments: Avoid skin contact with liquid bromoform or inhalation of its vapor.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Bromoform	**DOT Label:** Poison	**IMO Class:** 6.1
DOT ID No. UN2515	**DOT Class:** Poison B	**IMO Label:** St. Andrew's Cross (X)*

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

References: 1, 2, 12, 73, 84-94, 100, 103.

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GENIUM PUBLISHING CORP.

No. 676

BENZALDEHYDE

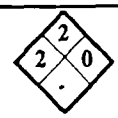
Issued: November 1988

SECTION 1. MATERIAL IDENTIFICATION

27

Material Name: BENZALDEHYDE

Description (Origin/Uses): Used in the manufacture of dyes, perfumes, cinnamic and mandelic acids; also used as a solvent and as a synthetic flavoring agent.



Other Designations: Artificial Almond Oil; Benzene Carbaldehyde; Benzenecarbonal; Benzoic Aldehyde; C_6H_5CHO; CAS No. 0100-52-7

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

HMIS	
H 2	R 1
F 2	I –
R 0	S 2
PPG*	K 2

*See sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
Benzaldehyde, CAS No. 0100-52-7	Ca 100	**OSHA PEL** None Established **ACGIH TLV, 1988-89** None Established **NIOSH REL** None Established **Toxicity Data*** Rat, Oral, LD_{50}: 1300 mg/kg Mouse, Oral, LD_{50}: 28 mg/kg
*See NIOSH, *RTECS* (CU4375000), for additional data with references to irritative and mutagenic effects.		

SECTION 3. PHYSICAL DATA

Boiling Point: 354°F (179°C)
Melting Point: -69.7°F (-56.5°C)
% Volatile by Volume: Ca 100
Vapor Density (Air = 1): 3.7

Molecular Weight: 106 Grams/Mole
Solubility in Water (%): Insoluble
Specific Gravity (H_2O = 1): 1.1

Appearance and Odor: A strongly refractive liquid that gradually yellows during prolonged storage; characteristic odor of the volatile oil of almond; burning, aromatic taste.

Comments: Benzaldehyde FFC denotes a grade of benzaldehyde that is free from chlorine contamination.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point: 145°F (63°C)	Autoignition Temperature: 37°F (192°C)	LEL: Not Found	UEL: Not Found

Extinguishing Media: Use water spray, dry chemical, foam, or carbon dioxide to extinguish benzaldehyde fires. Use water spray to cool fire-exposed containers, to disperse the vapor generated by an unignited benzaldehyde leak or spill, and to flush unignited spills away from sources of ignition.

Unusual Fire or Explosion Hazards: Benzaldehyde vapor is almost four times as dense as air (see sect. 3), so it can quickly collect in low-lying, confined rooms. Eliminate sources of ignition, particularly in these areas where explosive air-vapor mixtures can form. This also serves to prevent a dangerous flashback to the original liquid source of the benzaldehyde vapor.

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 5. REACTIVITY DATA

Stability/Polymerization: Benzaldehyde is stable in closed, airtight containers during routine operations at room temperature. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Benzaldehyde reacts dangerously with performic acid (Genium ref. 84).

Conditions to Avoid: Prevent exposing benzaldehyde to sources of ignition such as open flame, lighted tobacco products, steam lines, and sparks.

Hazardous Products of Decomposition: Benzaldehyde fires can produce toxic gases such as carbon monoxide (CO).

Comments: Benzaldehyde slowly oxidizes in air to benzoic acid.

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SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: Benzaldehyde is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: Benzaldehyde acts as a local anesthetic; however, skin and eye contact result in irritation. Small oral doses of this liquid cause depression of the central nervous system (CNS). Inhalation of high concentrations of benzaldehyde vapor can cause narcosis and convulsions. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, and the CNS. **Primary Entry:** Inhalation, skin contact. **Acute Effects:** Irritation to the mouth, throat, eyes, and skin. Mild irritation to the lungs and GI tract causing nausea and abdominal pain. Higher doses bring about narcotic-like effects, and convulsions and paralysis may occur after heavy exposure. **Chronic Effects:** May cause kidney damage; contact dermatitis may develop. **FIRST AID: Eyes.** Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. **Skin.** Rinse the affected area with flooding amounts of water, then wash it with soap and water **Inhalation:** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. Keep exposed person warm and at rest until medical help is available. **Ingestion.** Unlikely because benzaldehyde has a burning aromatic taste. Gastric lavage may be preferred to emesis. ***Get medical help (in plant, paramedic, community) for all exposures.*** *Seek prompt medical assistance for further treatment,* observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, and eliminate sources of ignition. Cleanup personnel must use nonsparking tools and equipment. Cleanup personnel should have appropriate respiratory protection (see sect. 8). Absorb the spilled benzaldehyde on vermiculite, sand, or earth, and place it into closable containers for disposal. **Waste 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): Not Listed
EPA Designations (40 CFR 302.4): Not Listed

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of benzaldehyde is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (leaks or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, *aprons, gauntlets, etc., to prevent repeated or prolonged skin contact with benzaldehyde.* **Ventilation:** *Install and operate general and local* maximum ventilation systems powerful enough to maintain airborne levels of this material that will not interfere with workers' safety, comfort, or productivity. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work 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 your shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off 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 benzaldehyde vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store benzaldehyde in closed, airtight containers in a cool, dry, well-ventilated area away from oxidizing materials and acute fire hazards. **Special Handling/Storage:** A first-in, first-out inventory storage system may prove useful if discoloration of the benzaldehyde is unacceptable.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Benzaldehyde
DOT Hazard Class: Combustible Liquid
ID No. NA1989

References: 1, 6, 84-94, 116, 117.

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 677

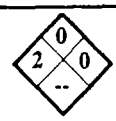
1,1,2,2-TETRACHLOROETHANE

Issued: November 1988

SECTION 1. MATERIAL IDENTIFICATION

27

Material Name: 1,1,2,2-TETRACHLOROETHANE



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Description (Origin/Uses): Used as a solvent primarily for cleaning and extraction procedures and as a chemical intermediate in the manufacture of trichloroethylene and tetrachloroethylene; and as an analytic reagent by textile manufacturers in polymer characterization tests.

Other Designations: Acetylene Tetrachloride; *sym*-Tetrachloroethane; $CHCl_2CHCl_2$; CAS No. 0079-34-5

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

HMIS

H	2	R	1
F	0	I	4
R	0	S	–
PPG*		K	–

*See sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
1,1,2,2-Tetrachloroethane, CAS No. 0079-34-5	Ca 100	**OSHA PEL (Skin*)** 8-Hr TWA: 1 ppm, 7 mg/m³ **ACGIH TLV (Skin*), 1988-89** TLV-TWA: 1 ppm, 7 mg/m³ **Toxicity Data**** Human, Oral, TD_{Lo}: 30 mg/kg Human, Inhalation, TC_{Lo}: 1000 mg/m³ (30 Mins) Rat, Oral, LD_{50}: 800 mg/kg

*This material can be absorbed through intact skin, which contributes to overall exposure.

**See NIOSH, *RTECS* (KI8575000), for additional data with references to reproductive, tumorigenic, and irritative effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 295°F (146°C)
Melting Point: -47°F (-44°C)
% Volatile by Volume: Ca 100
Vapor Pressure: 6 Torrs at 77°F (25°C)*
Molecular Weight: 168 Grams/Mole
Solubility in Water (%): Insoluble
Specific Gravity (H_2O = 1): 1.58658 at 77°F (25°C)

Appearance and Odor: A colorless, nonflammable, heavy, mobile liquid; sweetish, suffocating, characteristic chloroform odor. The odor recognition threshold is reported to be less than 3 ppm.

*At 77°F (25°C) the concentration of 1,1,2,2-tetrachloroethane in saturated air is approximately 7900 ppm.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature*	LEL*	UEL*

Extinguishing Media: *1,1,2,2-Tetrachloroethane does not burn. Use extinguishing agents that will put out the surrounding fire. **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 to protect against the effects of the nearby fire.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: 1,1,2,2-Tetrachloroethane is stable in closed containers during routine operations at room temperature. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Hazardous reactions between 1,1,2,2-tetrachloroethane and 2,4-dinitrophenyl disulfide, nitrogen tetroxide, chemically active metals such as potassium; and strong caustics such as potassium hydroxide, sodium, sodium-potassium alloy, hot iron, aluminum, and zinc in the presence of steam are reported. **Conditions to Avoid:** Prevent exposure to the incompatible chemicals listed above. Contact with water causes appreciable hydrolysis that will degrade and decompose this liquid. **Hazardous Products of Decomposition:** Thermal-oxidative degradation of 1,1,2,2-tetrachloroethane can produce highly toxic gases such as carbon monoxide (CO) and oxides of chlorine (ClO_x).

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: NIOSH lists 1,1,2,2-tetrachloroethane as a carcinogen.
Summary of Risks: 1,1,2,2-Tetrachloroethane is absorbed through intact skin in significant amounts; one human fatality has been attributed to this route of exposure. This liquid is considered to be one of the most toxic of the common chlorinated hydrocarbons, particularly with respect to the liver. Severely acute exposure causes depression of the central nervous system (CNS), which can cause death within 12 hours. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, respiratory system, CNS, gastrointestinal system, liver, and kidneys. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** The initial symptoms of exposure are lacrimation, salivation, and irritation of the nose and throat; continued exposure can lead to nausea, vomiting, and narcosis. Also, low blood pressure and cardiac rhythm abnormalities; respiratory depression; nausea, vomiting, burns of the esophagus, and diarrhea; and anesthesia with dizziness leading to loss of consciousness and coma; plus possible transient liver and kidney changes. **Chronic Effects:** The two sets of manifestations are (1) malaise, drowsiness, decreased appetite, then nausea and retching, a bad taste in the throat, constipation, headache, pale stools, jaundice, and dark urine, as well as mental confusion, stupor, and coma; and (2) hand

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SECTION 6. HEALTH HAZARD INFORMATION, cont.

tremors, sensation of deafness, numbness in hands and feet, a decrease in reflexes, headache, and nausea. FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. Skin. Rinse the affected areas with flooding amounts of water, then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. Keep the exposed person warm and at rest until medical help is available. **Ingestion.** Unlikely. Should this type of exposure occur, give the exposed person 3 glasses of water to drink and induce vomiting, then repeat this procedure. **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid. **Note to Physician:** Workers exposed to this liquid should be evaluated with a full battery of tests for the liver, kidneys, and CNS systems, as well as the blood.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, and provide adequate ventilation. Cleanup personnel must be properly clothed and equipped to protect the skin and eyes against any contact with the liquid as well as inhalation of its vapor (see sect. 8). Vacuum the spilled 1,1,2,2-tetrachloroethane and pump it into suitable containers for disposal. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).
EPA Designations (40 CFR 302.4)
RCRA Waste, No. U209
CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg), per the Clean Water Act (CWA), § 307 (a); and the Resource Conservation and Recovery Act (RCRA), § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of this liquid is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, gauntlets, etc., to prevent skin contact with this liquid. **Ventilation:** Install and operate general and local ventilation systems powerful enough to maintain airborne levels of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work 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 your shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off 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 1,1,2,2-tetrachloroethane vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store 1,1,2,2-tetrachloroethane in closed, airtight containers in a cool, dry, well-ventilated area away from incompatible chemicals (see sect. 5). **Special Handling/Storage:** Provide storage areas with adequate ventilation to prevent concentrations of the vapor from building up beyond the occupational exposure limits cited in section 2.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Tetrachloroethane
DOT Hazard Class: ORM-A
ID No. UN1702
DOT Packaging Requirements: 49 CFR 173.620
DOT Packaging Exceptions: 49 CFR 173.505

IMO Shipping Name: 1,1,2,2-Tetrachloroethane
IMO Hazard Class: 6.1
IMO Label: Poison
IMDG Packaging Group: II

References: 1, 38, 84-94, 100, 116, 117, 120, 122.

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Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 679

1,1,2-TRICHLOROETHANE

Issued: November 1988

SECTION 1. MATERIAL IDENTIFICATION

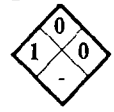
27

Material Name: 1,1,2-TRICHLOROETHANE

Description (Origin/Uses): Prepared by the catalytic chlorination of ethane or ethylene. Used as a solvent for fats, waxes, natural resins, and alkaloids.

Other Designations: ß-Trichloroethane; Ethane Trichloride; Vinyl Trichloride; $CH_2ClCHCl_2$; CAS No. 0079-00-5

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



Genium

HMIS

H	1	R	1
F	0	I	4
R	0	S	2
PPG*		K	0

*See sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

	%	EXPOSURE LIMITS
1,1,2-Trichloroethane, CAS No. 0079-00-5	Ca 100	**OSHA PEL (Skin*)** 8-Hr TWA: 10 ppm, 45 mg/m³ **ACGIH TLV (Skin*), 1988-89** TLV-TWA: 10 ppm, 45 mg/m³ **NIOSH REL** Lowest Feasible Level **Toxicity Data**** Rat, Oral, LD_{50}: 580 mg/kg Rat, Inhalation, LC_{Lo}: 500 ppm (8 Hrs)

*This material can be absorbed through intact skin, which contributes to overall exposure.
**See NIOSH, *RTECS* (KJ3150000), for additional data with references to irritative, tumorigenic, and mutagenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 237°F (114°C)
Melting Point: -33°F (-36°C)
% Volatile by Volume: 100
Vapor Pressure: 19 Torrs at 68°F (20°C)
Molecular Weight: 133 Grams/Mole
Solubility in Water (%): Insoluble
Specific Gravity (H_2O = 1): 1.4416 at 68°F (20°C)

Appearance and Odor: A colorless, nonflammable liquid; sweet, pleasant odor resembling chloroform.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature*	LEL*	UEL*

Extinguishing Media: *1,1,2-Trichloroethane does not burn. Use an extinguishing agent such as "alcohol" foam, water spray, carbon dioxide, or dry chemical to put out the surrounding fire.

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 to protect against the harmful effects of the surrounding fire.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: 1,1,2-Trichloroethane is stable in closed containers during routine operations at room temperature. Hazardous polymerization cannot occur.

Chemical Incompatibilities: 1,1,2-Trichloroethane can react dangerously with strong caustics such as sodium hydroxide and chemically active metals such as sodium, potassium, powdered magnesium, aluminum, and sodium-potassium alloys.

Conditions to Avoid: Prevent exposure to these incompatible materials.

Hazardous Products of Decomposition: Thermal-oxidative degradation of this liquid can produce toxic gases such as carbon monoxide (CO) and oxides of chlorine (ClO_x).

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SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: 1,1,2-Trichloroethane is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: Inhaling 1,1,2-trichloroethane vapor or absorbing the liquid through the skin depresses the central nervous system (CNS), which can progress to narcosis. Administration of this liquid to experimental animals has produced liver damage (fatty degeneration) and has induced cancer of the liver in mice. 1,1,2-Trichloroethane is 10 to 20 times more toxic than the trichloroethylene congener. **Medical Conditions Aggravated by Long-Term Exposure:** Persons with a history of chronic respiratory, liver, or kidney disease may be at increased risk from exposure to this liquid. Preplacement questionnaires are recommended. **Target Organs:** Skin, eyes, CNS, respiratory system, liver, and kidneys. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** Irritation of skin, eyes, nose, throat, and mucous membranes; and anesthesia manifested by CNS effects such as headache, dizziness, drowsiness, and incoordination. **Chronic Effects:** Liver and kidney damage and eventually coma and death may occur. Removal from exposure will reverse this progression.
FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. **Skin.** Rinse the affected area with flooding amounts of water, then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. Keep the exposed person warm and at rest until medical help is available. **Ingestion.** Unlikely. **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, and provide adequate ventilation. Cleanup personnel should wear protective clothing and equipment (see sect. 8). Soak up the spilled 1,1,2-trichloroethane onto a suitable absorbent such as vermiculite or sawdust and place it into containers suitable for disposal. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).

EPA Designations (40 CFR 302.4)

RCRA Waste, No. U227

CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg), per the Clean Water Act (CWA), § 307 (a); and the Resource Conservation and Recovery Act (RCRA), § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets, etc., to prevent skin contact with 1,1,2-trichloroethane. **Ventilation:** Install and operate general and local ventilation systems powerful enough to maintain airborne levels of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work 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 your shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off 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 1,1,2-trichloroethane vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store 1,1,2-trichloroethane in closed containers in a cool, dry, well-ventilated area away from incompatible chemicals (see sect. 5). **Special Handling/Storage:** Storage facilities must have adequate ventilation because this volatile liquid can evaporate and build up hazardous concentrations in these areas.

Transportation Data (49 CFR 172.101-2): Not Listed

References: 1, 38, 84-94, 100, 116, 117, 120, 122.

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Material Safety Data Sheets Collection:

Sheet No. 683
Polychlorinated Biphenyls (PCBs)

Issued: 11/88 Revision: A, 9/92

Section 1. Material Identification

Polychlorinated Biphenyls [$C_{12}H_{10-n}Cl_n$ (n=3, 4, 5)] Description: A class of nonpolar chlorinated hydrocarbons with a biphenyl nucleus (two benzene nuclei connected by a single C-C bond) in which any or all of the hydrogen atoms have been replaced by chlorine. Commercial PCBs are mixtures of chlorinated biphenyl isomers with varying degrees of chlorination. Prepared industrially by the chlorination of biphenyl with anhydrous chlorine in the presence of a catalyst such as ferric chloride or iron filings. Except for limited research and development applications, PCBs have not been produced in the US since 1977. When large quantities of PCBs were manufactured in the US, they were marketed under the tradename Aroclor (Monsanto) and were characterized by four digit numbers. The first two digits indicating biphenyls (12), triphenyls (54), or both (25, 44); the last two digits indicating the weight percent of chlorine. PCBs' thermal stability, nonflammability, and high dielectric capability made them very useful in electrical equipment. Formerly used as additives in hydraulic fluids, heat transfer systems, lubricants, cutting oils, printer's ink, fire retardants, asphalt, brake linings, automobile body sealants, plasticizers, adhesives, synthetic rubber, floor tile, wax extenders, dedusting agents, pesticide extenders, and carbonless reproducing paper. PCBs are still used in certain existing electrical capacitors and transformers that require enhanced electrical protection to avoid heating from sustained electric faults.

R 1
I 4
S 3*
K 1
* Skin absorption

NFPA

HMIS
H 2‡
F 1
R 0
PPE†
† Sec. 8
‡ Chronic Effects

Other Designations: CAS No. 1336-36-3, Aroclor, Clophen, Chlorextol, chlorinated biphenyls, chlorinated diphenyl, chlorinated diphenylene, chloro biphenyl, chloro-1,1-biphenyl, Dykanol, Fenclor, Inerteen, Kaneclor, Montar, Noflamol, Phenoclor, Pyralene, Pyranol, Santotherm, Sovol, Therminol FR-1

Cautions: PCBs are potent liver toxins that may be absorbed through skin. Potentially, chronic or delayed toxicity is significant because PCBs accumulate in fatty tissue and may reasonably be anticipated to be carcinogens. PCBs are a bioaccumulative environmental hazard. When burned, decomposition products may be more hazardous than the PCBs.

Section 2. Ingredients and Occupational Exposure Limits

PCBs, contain various levels of polychlorinated dibenzofurans and chlorinated naphthalenes as contaminants

1991 OSHA PELs, Skin
8-hr TWA (Chlorodiphenyl, 42% chlorine): 1 mg/m³
8-hr TWA (Chlorodiphenyl, 54% chlorine): 0.5 mg/m³

1990 DFG (Germany) MAK, Danger of Cutaneous Absorption
TWA (Chlorodiphenyl, 42% chlorine): 0.1 ppm (1 mg/m³)
Category III: Substances with systemic effects, onset of effect > 2 hr., half-life > shift length (strongly cumulative)
Short-term Level: 1 ppm, 30 min., average value, 1 per shift
TWA (Chlorodiphenyl, 54% chlorine): 0.05 ppm (0.5 mg/m³)
Category III: (see above)
Short-term Level: 0.5 ppm, 30 min., average value, 1 per shift

1985-86 Toxicity Data*
Rat, oral, TD: 1250 mg/kg administered intermittently for 25 weeks produced liver tumors.
Mammal, oral, TD_{Lo}: 325 mg/kg administered to female for 30 days prior to mating and from the 1st to the 36th day of gestation produced effects on newborn (stillbirth; live birth index; viability index).

1990 NIOSH REL
TWA (Chlorodiphenyl, 42% chlorine): 0.001 mg/m³
TWA (Chlorodiphenyl, 54% chlorine): 0.001 mg/m³

1992-93 ACGIH TLVs, Skin *
TWA (Chlorodiphenyl, 42% chlorine): 1 mg/m³
TWA (Chlorodiphenyl, 54% chlorine): 0.5 mg/m³

* These guidelines offer reasonably good protection against systemic intoxication, but may not guarantee that chloroacne won't occur.
† See NIOSH, *RTECS* (TQ1350000), for additional reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data*

Boiling Point: 644-707 °F (340-375 °C)
Melting Point: 42%: -2.2 °F (-19°C); 54%: 14 °F (-10 °C)
Vapor Pressure: 1 mm Hg at 100 °F (38 °C); 10^{-6} to 10^{-3} mm at 20 °C
Molecular Weight: 188.7 to 398.5
Specific Gravity: 1.3 to 1.8 at 20 °C
Water Solubility: Low solubility (0.007 to 5.9 mg/L)
Other Solubilities: Most common organic solvents, oils, and fats; slightly soluble in glycerol and glycols.

Appearance and Odor: PCBs vary from mobile oily liquids to white crystalline solids and hard non-crystalline resins, depending upon chlorine content.

* Physical and chemical properties vary widely according to degree and to the position of chlorination.

Section 4. Fire and Explosion Data

Flash Point: 286-385 °F (141-196 °C) OC*	Autoignition Temperature: 464 °F (240 °C)	LEL: None reported	UEL: None reported

Extinguishing Media: Use extinguishing media suitable to the surrounding fire. Use dry chemical, foam, carbon dioxide (CO_2), or water spray. Water spray may be ineffective. Use water spray to cool fire-exposed containers or transformers. Do not scatter PCBs with high-pressure water streams. **Unusual Fire or Explosion Hazards:** Combustion products (hydrogen chloride, phosgene, polychlorinated dibenzofurans, and furans) are more hazardous than the PCBs themselves. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Approach fire from upwind to avoid highly toxic decomposition products. Structural firefighter's protective clothing will provide *limited* protection. Do not release runoff from fire control methods to sewers or waterways. Dike for later disposal.

* Flash points shown are a range for various PCBs. Some forms do not have flash points.

Section 5. Reactivity Data

Stability/Polymerization: PCBs are very stable materials but are subject to photodechlorination when exposed to sunlight or UV (spectral region above 290 nanometers). Hazardous polymerization cannot occur. **Chemical Incompatibilities:** PCBs are chemically inert and resistant to oxidation, acids, and bases. **Conditions to Avoid:** Avoid heat and ignition sources.
Hazardous Products of Decomposition: Thermal oxidative decomposition [1112-1202 °F (600-650 °C)] of PCBs can produce highly toxic derivatives, including polychlorinated dibenzo-para-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hydrogen chloride, phosgene and other irritants.

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Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] and NTP[169] list PCBs as an IARC probable carcinogen (overall evaluation is 2A; limited human data; sufficient animal data) and NTP anticipated carcinogen, respectively. **Summary of Risks:** PCBs are potent liver toxins that can be absorbed through unbroken skin in toxic amounts without immediate pain or irritation. PCBs have low acute toxicity, but can accumulate in fatty tissue and severe health effects may develop later. Generally, toxicity increases with a higher chlorine content; PCB-oxides are more toxic. The toxic action on the liver also increases with simultaneous exposure to other liver toxins, e.g. chlorinated solvents, alcohol, and certain drugs. Pathological pregnancies (abnormal pigmentations, abortions, stillbirths, and underweight births) have been associated with increased PCB serum levels in mothers; PCBs can be passed in breast milk. PCBs can affect the reproductive system of adults. **Medical Conditions Aggravated by Long-Term Exposure:** Skin, liver, and respiratory disease. **Target Organs:** Skin, liver, eyes, mucous membranes, and respiratory tract. **Primary Entry Routes:** Inhalation, dermal contact, ingestion. **Acute Effects:** Exposure to PCB vapor or mist is severely irritating to the skin, eyes, nose, throat, and upper respiratory tract. Intense acute exposure to high concentrations may result in eye, lung, and liver injury. Systemic effects include nausea, vomiting, increased blood pressure, fatigue, weight loss, jaundice, edema and abdominal pain. Cognitive, neurobehavior and psychomotor impairment and memory loss have also been seen after acute exposure. **Chronic Effects:** Repeated exposure to PCBs can cause chloroacne; redness, swelling, dryness, thickening and darkening of the skin and nails; swelling and burning of the eyes, and excessive eye discharge; distinctive hair follicles; gastrointestinal disturbances; neurological symptoms including headache, dizziness, depression, nervousness, numbness of the extremities, and joint and muscle pain; liver enlargement; menstrual changes in women; and chronic bronchitis. Cancer, primarily liver, is also a possible result of exposure, but data is inconclusive.

FIRST AID Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Rinsing eyes with medical oil (olive, mineral) initially may remove PCB and halt irritation better than water rinsing alone. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. *Multiple soap and water washings are necessary.* Avoid the use of organic solvents to clean the skin. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** In most cases, accidental PCB ingestion will not be recognized until long after vomiting would be of any value. Never give anything by mouth to an unconscious or convulsing person. Vomiting of the pure substance may cause aspiration. Consult a physician. **Note to Physicians:** Monitor patients for increased hepatic enzymes, chloroacne, and eye, gastrointestinal, and neurologic symptoms listed above. Diagnostic tests include blood levels of PCBs and altered liver enzymes.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, provide adequate ventilation, and isolate hazard area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. For small spills, take up with sand or other noncombustible material and place into containers for later disposal. For larger spills, dike far ahead of spill to contain for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** PCBs have been shown to bio-concentrate significantly in aquatic organisms. **Ecotoxicity:** Bluegill, TLm: 0.278 ppm/96 hr. Mallard Duck, LD_{50}: 2000 ppm. **Environmental Degradation:** In general, the persistence of PCBs increases with an increase degree of chlorination. **Soil Absorption/Mobility:** PCBs are tightly absorbed in soil and generally do not leach significantly in most aqueous soil systems. However, in the presence of organic solvents, PCBs may leach rapidly through the soil. Volatilization of PCBs from soil may be slow, but over time may be significant. **Disposal:** Approved PCB disposal methods include: incineration with scrubbing, high-efficiency boilers, landfills, and EPA-approved alternative disposal methods. Each disposal method has various criteria. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1 lb (0.454 kg) [* per CWA, Sec. 311(b)(4) and 307(a)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. Minimum respiratory protection should include a combination dust-fume-mist and organic vapor cartridge or canister or air-supplied, depending upon the situation. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. Butyl rubber, neoprene, Teflon, and fluorocarbon rubber have break through times greater than 8 hrs. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Segregate contaminated clothing in such a manner so that there is no direct contact by laundry personnel. Implement quality assurance to ascertain the completeness of the cleaning procedures. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a closed, labelled, container in a ventilated area with appropriate air pollution control equipment. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Inform employees of the adverse health effects associated with PCBs. Limit access to PCB work areas to authorized personnel. Consider preplacement and periodic medical examinations with emphasis on the skin, liver, lung, and reproductive system. Monitor PCB blood levels. Consider possible effects on the fetus. Keep medical records for the entire length of employment and for the following 30 yrs.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Polychlorinated biphenyls
DOT Hazard Class: 9
ID No.: UN2315
DOT Packing Group: II
DOT Label: CLASS 9
Special Provisions (172.102): 9, N81

Packaging Authorizations
a) Exceptions: 173.155
b) Non-bulk Packaging: 173.202
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 100 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 34

MSDS Collection **References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 163, 164, 168, 169, 174, 175, 180
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy MPH, CIH; **Medical Review:** AC Darlington, MD

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Material Safety Data Sheets Collection:

Sheet No. 703
1,2-Dichloroethylene

Issued: 4/90

Section 1. Material Identification

31

1,2-Dichloroethylene Description: An industrial solvent composed of 60% cis- and 40% trans-isomers. Both isomers, cis and trans, are made by partial chlorination of acetylene. Used as a general solvent for organic materials, lacquers, dye extraction, thermoplastics, organic synthesis, and perfumes. The trans-isomer is more widely used in industry than either the cis-isomer or the mixture. Toxicity also varies between the two isomers.

Other Designations: CAS No. 0540-59-0; $C_2H_2Cl_2$; acetylene dichloride; *cis*-1,2-dichloroethylene; *sym*-dichloroethylene; *trans*-1,2-dichloroethylene, dioform.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

R 1
I 2
S 2
K 1

NFPA

HMIS
H 2
F 3
R 1
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

1,2-Dichloroethylene, ca 100%

OSHA PEL
8-hr TWA: 790 mg/m³, 200 ppm

ACGIH TLV, 1989-90
TLV-TWA: 790 mg/m³, 200 ppm

NIOSH REL, 1987
790 mg/m³, 200 ppm

Toxicity Data*
Rat, oral, LD_{50}: 770 mg/kg; toxic effects not yet reviewed
Frog, inhalation, TC_{Lo}: 117 mg/m³ inhaled for 1 hr affects the peripheral nerve and sensation (flaccid paralysis without anesthesia); behavior (excitement); lungs, thorax, or respiration (respiratory depression)

* See NIOSH, *RTECS* (KV9360000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 119 °F/48 °C
Melting Point: -56 to -115 °F/-49 to -82 °C/
Vapor Pressure: 180 to 264 torr at 68 °F/20 °C
Vapor Density (Air = 1): 3.4
Molecular Weight: 96.95 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.27 at 77 °F/25 °C
Water Solubility: Insoluble

Appearance and Odor: A colorless, low-boiling liquid with a pleasant odor.

Section 4. Fire and Explosion Data

Flash Point: 37 °F/2.8 °C, CC	Autoignition Temperature: 860 °F/460 °C	LEL: 5.6% v/v	UEL: 12.8% v/v

Extinguishing Media: Use dry chemical, CO_2, halon, water spray, or standard foam. Water may be ineffective unless used to blanket the fire.
Unusual Fire or Explosion Hazards: This material's vapors are a dangerous fire hazard and moderate explosion hazard when exposed to any heat or ignition source or oxidizer.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and a fully encapsulating suit. Vapors may travel to heat or ignition sources and flash back. Stay upwind and out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: This material is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: This material is incompatible with alkalies, nitrogen tetraoxide, difluoromethylene, strong oxidizers, and dihypofluorite. When in contact with copper or copper alloys or by reaction with potassium hydroxide, explosive chloroacetylene may be released.
Conditions to Avoid: Addition of hot liquid to cold 1,2-dichloroethylene may cause sudden emission of vapor that could flash back to an ignition source.
Hazardous Products of Decomposition: Thermal oxidative decomposition of 1,2-dichloroethylene can produce highly toxic fumes of chlorine (Cl^-).

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists 1,2-dichloroethylene as a carcinogen.

Summary of Risks: 1,2-Dichloroethylene's most important effect is its irritation of the central nervous system (CNS) and narcosis. This material is toxic by inhalation, ingestion, and skin contact. It is also irritating to the eyes. The trans-isomer at 2200 ppm causes nausea, vertigo, and burning of the eyes. The trans-isomer is twice as potent as the cis-isomer. If renal effects occur, they are transient.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Target Organs: Central nervous system, eyes, respiratory system.

Primary Entry Routes: Inhalation, ingestion, skin and eye contact.

Acute Effects: Inhalation of 1,2-dichloroethylene causes narcosis, respiratory tract irritation, nausea, vomiting, tremor, weakness, central nervous depression, and epigastric (the abdomen's upper midregion) cramps. Contact with the liquid causes eye and skin (on prolonged contact) irritation. Ingestion causes slight depression to deep narcosis.

Chronic Effects: None reported.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed. Have trained personnel administer 100% oxygen, preferably with humidification.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Physician's Note: Intravenous injections of calcium gluconate may relieve cramps and vomiting. Treat central nervous system effects symptomatically.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a 1,2-dichloroethylene spill control and countermeasure plan (SCCP).* Notify safety personnel, remove all heat and ignition sources, evacuate hazard area, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation and skin or eye contact. Absorb small spills on paper towels. After evaporating the 1,2-dichloroethylene from these paper towels in a fume hood, burn the paper in a suitable location away from combustible material. Collect and atomize large quantities in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. Follow applicable OSHA regulations (29 CFR 1910.120).

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

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per RCRA, Sec. 3001, per Clean Water Act, Sec. 307(a)]†

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

† Listed as 1,2-*trans*-dichloroethylene.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.

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

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. 1,2-dichloroethylene attacks some forms of plastics, rubber, and coatings.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, well-ventilated area away from all incompatible materials (Sec. 5) and oxidizing materials. Outside or detached storage is preferred. If stored inside, place containers in a standard flammable liquids storage cabinet or room. Protect containers from physical damage.

Engineering Controls: Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. 1,2-dichloroethylene is a dangerous fire hazard. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Provide preplacement questionnaires which emphasize detecting a history of chronic respiratory disease.

Transportation Data (49 CFR 172.101, .102): Not listed

***MSDS Collection* References:** 7, 26, 38, 73, 84, 85, 87, 88, 100, 101, 103, 109, 126, 127, 136, 137

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

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Material Safety Data Sheets Collection:

Sheet No. 708
Vinylidene Chloride

Issued: 4/90

Section 1. Material Identification

31

Vinylidene Chloride Description: Prepared from ethylene chloride. Also prepared from vinyl chloride by successive chlorination and dehydrochlorination steps. Used primarily as a co-monomer in producing vinylidene copolymers (Saran®, Velon®) for films and coatings. Also used in producing methyl chloroform, vinyl chloride resins, plastics, chloracetyl chloride; in adhesives; as a component of synthetic fibers; a chemical intermediate in vinylidene fluoride synthesis; and for 1,1,1-trichloroethane. A common constituent in our environment, measurable quantities of vinylidene chloride are found in poorly ventilated areas with a high concentration of plastics. It is a notable contaminant in recycled air environments such as nuclear submarines and spacecraft.
Other Designations: CAS No. 0075-35-4; $C_2H_2Cl_2$; 1,1-DCE; 1,1-dichloroethene; *asym*-dichloroethylene; VDC; vinylidene dichloride.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.
Comment: At temperatures above 32 °F/0 °C and especially in the presence of oxygen or other suitable catalysts, vinylidene chloride polymerizes to a plastic. Therefore, commercial products may contain small proportions of inhibitors to preserve the monomer.

R 3
I 4
S 2
K 4

NFPA

HMIS
H 2
F 4
R 2
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Vinylidene chloride, ca 100%

OSHA PEL
8-hr TWA: 1 ppm, 4 mg/m³

ACGIH TLVs, 1989-90
TLV-TWA: 5 ppm, 20 mg/m³
TLV-STEL: 20 ppm, 79 mg/m³

NIOSH REL, 1987
None established

Toxicity Data*
Mouse, skin, TD_{Lo}: 4840 mg/kg has tumorigenic effects on skin, appendages, lungs, thorax, and respiration
Rat, inhalation, LC_{50}: 6350 ppm/4 hr
Human, inhalation, TC_{Lo}: 25 ppm produces changes in behavior (general anesthetic), the liver, kidney, ureter, and bladder

* See NIOSH, *RTECS* (YZ8061000), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 89.1 °F/31.7 °C at 760 mm Hg
Melting Point: -188.5 °F/-122.5 °C
Vapor Pressure: 591 mm Hg at 77 °F/25 °C
Vapor Density (Air = 1): 3.4
Molecular Weight: 96.94 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.2129 at 68 °F/20 °C
Water Solubility: Sparingly soluble (0.04 % wt/vol in water at 68 °F/20 °C)

Appearance and Odor: Colorless, volatile liquid with a mild, sweet odor that resembles chloroform. Most persons can detect vinylidene chloride at 1000 ppm, but others can detect it at less than 500 ppm. Neither odor is adequate to warn of excessive exposure.

Section 4. Fire and Explosion Data

Flash Point: -19 °F/-28 °C	Autoignition Temperature: 1058 °F/570 °C	LEL: 5.6% v/v	UEL: 11.4% v/v

Extinguishing Media: Use dry chemical, alcohol foam, or carbon dioxide. Use water to cool fire-exposed containers.
Unusual Fire or Explosion Hazards: Vinylidene chloride is a very flammable and volatile liquid with a burning rate of 2.7 mm/min. This material is a very dangerous fire hazard and moderately explosive when exposed to heat or flame. It may explode spontaneously since the vapor forms explosive mixtures with air. At elevated temperatures, polymerization may take place and containers may rupture.
Special Fire-fighting Procedures: Since vinylidene chloride may be poisonous if inhaled or absorbed through the skin, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode with a fully encapsulating suit. Keep unnecessary people away from the hazard area. Vapors may travel to an ignition source and flash back. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Vinylidene chloride is self-reactive. If stored between -40 °F/-40 °C and 77 °F/25 °C in air without an inhibitor, this material rapidly absorbs oxygen and forms a violently explosive peroxide. The heat of polymerization is -185 cal/g (inhibited). When unstable, vinylidene chloride decomposes into chlorine, hydrogen chloride, phosgene, and formaldehyde. Hazardous polymerization can occur if exposed to sunlight, air, copper, aluminum, or heat.
Chemical Incompatibilities: This material reacts violently with chlorosulfonic acid, nitric acid, and oleum; and vigorously with oxidizing materials.
Hazardous Products of Decomposition: Thermal oxidative decomposition of vinylidene chloride can produce highly toxic fumes of chlorine (Cl_2) and hydrogen chloride (HCl).

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Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists vinylidene chloride as a carcinogen, although the ACGIH suggests it is a suspected carcinogen. Various animal studies suggest a high rate of cancer in species-specific testing; application to humans does not appear valid.
Summary of Risks: Vinylidene chloride is an irritant to the skin, eyes, and mucous membranes, although any inhibitor in vinylidene chloride may partly cause the irritation. VDC is narcotic at concentrations greater than 4000 ppm, and has caused liver and kidney injury in experimental animals. Solutions containing the inhibitor MEHQ (monomethyl ether of hydroquinone) may cause leucoderma (white skin) and serious eye injury.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, central nervous system, liver, and kidneys.
Primary Entry Routes: Inhalation.
Acute Effects: Inhalation of VDC causes narcosis and respiratory irritation. Concentrations of 4000 ppm lead to symptoms of drunkenness and eventually unconsciousness if the exposure continues. In monkey studies, exposure to 200 ppm caused acute liver injury with a mechanism similar to carbon tetrachloride. Animal studies indicate acute kidney changes in high-level exposures. Eye contact may cause conjunctivitis, transient corneal injury, and iritis. VDC also causes skin and mucous membrane irritation.
Chronic Effects: With chronic inhalation, vinylidene chloride may cause hepatic and renal dysfunction. In monkey studies, long-term inhalation at a 48-ppm level caused liver and kidney damage and death.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Solutions containing increased MEHQ concentrations are caustic and should not be removed by emesis. There is no specific treatment for VDC intoxication, but if significant amounts have been ingested, monitor the patient for liver and kidney failure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a vinylidene chloride spill control and countermeasure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel from hazard area, remove all heat and ignition sources, and ventilate area. Cleanup personnel should protect against inhalation and skin and eye contact. For lab spills, absorb the spill with paper towels and place in a hood to allow liquid to evaporate. For large spills, absorb bulk spill with cement powder, fly ash, sawdust, or commercial sorbents. Place waste in appropriate disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per Clean Water Act, Sec. 31 (b)(4), Sec. 307(a); per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Respiratory canisters containing alkaline materials should not be used because dichloro acetylene can be formed. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. Rubber gloves are recommended.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLVs (Sec. 2). Local explosion-proof exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store vinylidene chloride in tanks with nickel, glass, or baked phenolic linings at 14 °F/-10 °C in the absence of light, air, water, and other polymerization initiators under a nitrogen blanket (at 10-psi pressure and an oxygen content less than 100 ppm). Outside or detached storage is preferable. If stored inside, store in a standard flammable liquids storage cabinet separate from oxidizing materials and incompatible materials (Sec. 5).
Engineering Controls: VDC requires special handling, precautions, and employee training. Do not handle VDC without adequate ventilation and personal protective gear. Limit exposures to vinylidene chloride by improving housekeeping procedures. Keep VDC away from all heat and ignition sources. All engineering systems should be of maximum explosion-proof design, electrically grounded, and bonded.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Vinylidene chloride, inhibited
DOT Hazard Class: Flammable liquid
ID No.: UN1303
DOT Label: Flammable liquid
DOT Packaging Requirements: 173.119
DOT Packaging Exceptions: 173.118

IMO Shipping Name: Vinylidene chloride, inhibited
IMO Hazard Class: 3.1
IMO Label: Flammable liquid
IMDG Packaging Group: I
ID No.: UN1303

MSDS Collection **References:** 7, 26, 38, 53, 73, 84, 85, 87, 89, 100, 103, 124, 126, 127, 129, 134, 136
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheet

From Genium's Reference Collection
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GENIUM PUBLISHING CORP.

No. 634

ETHYL BROMIDE

Issued: November 1987

SECTION 1. MATERIAL IDENTIFICATION

Material Name: ETHYL BROMIDE

Description (Origin/Uses): Used primarily as a chemical intermediate.

Other Designations: Bromoethane; Monobromoethane; C_2H_5Br;
NIOSH *RTECS* No. KH6475000; CAS No. 0074-96-4

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

HMIS
H 2
F 3 R 1
R 0 I 2
PPG* S 2
*See sect. 8 K 4

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
Ethyl Bromide, CAS No. 0074-96-4 $Br - C_2H_5$ *Immediately dangerous to life and health **See NIOSH *RTECS* for additional data.	ca 100	IDLH* Level: 3500 ppm **ACGIH TLVs, 1987-88** TLV-TWA: 200 ppm, 890 mg/m³ TLV-STEL: 250 ppm, 1110 mg/m³ **OSHA PEL** 8-Hr TWA: 200 ppm, 890 mg/m³ **Toxicity Data**** Rat, Inhalation, LC_{Lo}: 148 ppt/15 Min Rat, Oral, LD_{50}: 1350 mg/kg

SECTION 3. PHYSICAL DATA

Boiling Point, 1 atm: 101.12°F (38.4°C)
Vapor Pressure: 375 Torr at 68°F (20°C)
Water Solubility at 20°C, % by Wt.: 2.0
Vapor Density (Air = 1): 3.8
Evaporation Rate (BuAc = 1): Not Found*

Specific Gravity (H_2O = 1): 1.4612 at 68°F (20°C)
Melting Point: -182.2°F (-119°C)
% Volatile by Volume: 100
Molecular Weight: 109 Grams/Mole

Appearance and Odor: Colorless liquid that turns yellowish on exposure to light and air; ethereal odor.
*Ethyl bromide is a highly volatile liquid that evaporates very rapidly compared to *n*-butyl acetate.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
<-4°F (<-20°C) CC	952°F (511°C)	% by Volume	6.75	11.25

Extinguishing Media: Use dry chemical, foam, or carbon dioxide. Water may be ineffective in extinguishing fire. Use water spray to cool fire-exposed tanks/containers and to disperse vapor.

Unusual Fire/Explosion Hazards: This OSHA class IA flammable liquid is a dangerous fire and explosion hazard when exposed to heat, sparks, or open flame. **Warning:** Ethyl bromide can react vigorously with oxidizing materials. Its vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back.

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 5. REACTIVITY DATA

Ethyl bromide is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization.

Chemical Incompatibilities: This material is incompatible with strong oxidizing agents. Contact with chemically active metals such as sodium, potassium, calcium, powdered aluminum, zinc, or magnesium may cause fires and explosions.

Conditions to Avoid: Liquid ethyl bromide will attack some forms of plastics, rubber, and coatings, so care is needed in the selection of safety and handling equipment such as respirators.

Hazardous Products of Decomposition: Thermal decomposition or burning produces carbon dioxide and/or carbon monoxide and toxic fumes of bromine.

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SECTION 6. HEALTH HAZARD INFORMATION

Ethyl bromide is not listed as a carcinogen by the NTP, IARC, or OSHA.

Summary of Risks: "The primary response to ethyl bromide is central nervous system depression (narcosis), as with ethyl chloride. In addition, . . . ethyl bromide produces irritation of the lungs, marked congestion of the liver and intestine with hemorrhage and cloudy swelling of the kidneys." Using ethyl bromide as an anesthetic is not recommended "because of its irritant action on the respiratory apparatus and its tendency to cause fatty degeneration of the liver, renal tissue, and the heart. Several deaths have been attributed to its use as a general anesthetic" (*Doc. TLVs, BEIs,* Genium ref. 89, p. 245). Symptoms of exposure include drowsiness, slurred speech, and incoordination. **Medical Conditions Aggravated by Long-Term Exposure:** Liver, kidneys, heart, and respiratory problems. **Target Organs:** Skin, eyes, respiratory system, liver, kidneys, and heart. **Primary Entry:** Inhalation, skin contact. **Acute Effects:** Skin, eye, and respiratory system irritation. **Chronic Effects:** 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. **Skin Contact.** Immediately wash the affected area with soap and water. **Inhalation.** Remove victim to fresh air; restore and/or support his breathing as needed. Keep him warm and quiet. **Ingestion.** Call a poison control center. Never give anything by mouth to someone who is unconscious or convulsing. If the victim is responsive, give him one or two glasses of milk or water to drink. Do *not* induce vomiting unless directed to do so by a physician.

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel of large ethyl bromide spills or leaks. Remove all sources of heat and ignition. Provide maximum explosion-proof ventilation. Evacuate the spill area and limit access to necessary personnel only. Remove leaking containers to a safe place, if feasible. Those involved in cleanup need protection against contact with liquid and inhalation of vapor (see sect. 8). Absorb small spills with paper toweling or vermiculite. Contain large spills and collect them, if feasible, or absorb them with an inert material such as sand, earth, or vermiculite. Place waste liquid or absorbent into closable containers for disposal, using nonsparking tools. Water spray may be used to flush spills away from sensitive exposures. Do not flush spills to sewers, watersheds, or waterways.
Waste Disposal: Consider reclamation, recycling, or destruction rather than disposal in a landfill. Contact your supplier or a licensed contractor for additional 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: Not Listed
CERCLA Hazardous Substance: Not Listed

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. **Gloves:** Wear impervious gloves; choose gloves carefully. **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. IDLH or unknown concentrations require 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 Equipment: Wear impervious aprons, boots, gauntlets, and any other personal protective equipment appropriate to the working conditions. **Ventilation:** Install and operate ventilation systems of sufficient power to maintain airborne levels of ethyl bromide below the OSHA PEL standard cited in section 2. All ventilation systems must be nonsparking and of maximum explosion-proof design.
Safety Stations: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling.
Contaminated Equipment: Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Remove and launder contaminated clothing before wearing it again; clean this material from shoes and equipment.
Comments: Practice good personal hygiene. Keep this material off of your clothing and equipment. Avoid transferring this material from hands to mouth while eating, drinking, or smoking. Do *not* smoke, eat, or drink in any immediate work area.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage Segregation: Store ethyl bromide in closed containers in a *cool*, dry, well-ventilated area away from oxidizing agents, heat, sparks, and open flame.
Special Handling/Storage: Storage area must meet OSHA requirements for class IA flammable liquids. Protect containers from physical damage.
Engineering Controls in the Workplace: Ground and bond metal containers and equipment when making transfers to prevent static sparks. Do not smoke in areas where this material is handled or stored. Emptied containers retain product residues; handle them accordingly!

Transportation Data (49 CFR 172.101-2)
DOT Shipping Name: Ethyl Bromide
DOT Hazard Class: Poison B
IMO Class: 6.1
DOT ID No. UN1891
IMO Label: Poison
DOT Label: Poison

References: 1, 2, 4, 5, 7-9, 12, 14, 25, 37, 38, 59, 69, 73, 81, 82, 84-94, 103. CR/PJI

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Approvals JC Dunlop 5/88
Indust. Hygiene/Safety [illegible] 5/88
Medical Review [illegible]

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Material Safety Data Sheet Collection

Phenanthrene **MSDS No. 905**

Date of Preparation: 6/94

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: Phenanthrene
Chemical Formula: $(C_6H_4CH)_2$
CAS No.: 85-01-8
Synonyms: Phenantrin
Derivation: A polynuclear aromatic hydrocarbon found as a component of coal tar pitch volatiles (products of bituminous coal distillation). Produced from toluene, bibenzil, 9-methyl fluorene or stilbene by passage through red hot tubes or by diene synthesis of 1-vinyl naphthalene and maleic anhydride.
General Use: Used in the manufacture of dyestuffs and explosives; in biological research or drug synthesis.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Phenanthrene, ca 100 % wt

OSHA PEL*
8-hr TWA: 0.2 mg/m^3

ACGIH TLV*
TWA: 0.2 mg/m^3

NIOSH REL*
10-hr TWA: 0.1 mg/m^3, *cyclohexane extractable fraction*

DFG (Germany) MAK
None established

*Coal tar pitch volatiles (benzene soluble)

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Phenanthrene exists as shiny crystals with a faint, aromatic odor. It can cause photosensitization of the skin. Phenanthrene is combustible and reacts dangerously with oxidizers.

Wilson Risk Scale
R 1
I 3
S 3
K 1

HMIS
H 1
F 1
R 0

PPE*
*Sec. 8

Potential Health Effects

Primary Entry Routes: Skin contact.
Target Organs: Skin.
Acute Effects
Inhalation: Effects not reported.
Eye: Effects not reported.
Skin: Can cause photosensitization of the skin.
Ingestion: Effects not reported.
Carcinogenicity: Although it has produced skin cancer in experimental animals, the results were not statistically significant and IARC has assigned phenanthrene a Class 3 (unclassifiable as to carcinogenicity) designation. The NTP and OSHA do not list phenanthrene as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: Skin disorders.
Chronic Effects: None reported.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed.
Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin Contact: *Quickly* remove contaminated clothing. Rinse exposed area with flooding amounts of water to remove loose material and then move quickly to a soap and water wash. For reddened or blistered skin, consult a physician.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Treatment is symptomatic and supportive.

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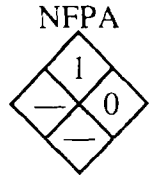
Section 5 - Fire-Fighting Measures



Flash Point: 340 °F (171 °C)
Flash Point Method: OC
LEL: Not reported.
UEL: Not reported.
Flammability Classification: Class IIIB Combustible liquid
Extinguishing Media: Use dry chemical or carbon dioxide; water spray or foam may cause frothing.
Unusual Fire or Explosion Hazards: None reported
Hazardous Combustion Products: Carbon oxides (CO_X) and acrid smoke
Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways.
Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against skin contact.
Small Spills: To avoid dust generation, *do not* sweep! Carefully scoop up or vacuum (with appropriate filter). Damp mop residue.
Large Spills
Containment: Flush large spill to containment area for later disposal. Do not release into sewers or waterways.
Cleanup: Mop up any residue.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Use nonsparking tools to open containers.
Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from heat, ignition sources, and strong oxidizers.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: To prevent static sparks, electrically ground and bond all equipment used with and around phenanthrene.
Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103)
Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the skin.
Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. The following respirator recommendation is for *coal-tar pitch volatiles*: For any detectable concentration, use a SCBA or supplied-air respirator (with auxiliary SCBA) with a full facepiece and operated in pressure-demand or other positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.
Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Solid
Appearance and Odor: Colorless, shiny crystals with a faint, aromatic odor.
Vapor Pressure: 1 mm Hg at 244.76 °F (118.2 °C); 400 mm Hg at 586.4 (308 °C)
Formula Weight: 178.22
Density (H_2O=1, at 4 °C): 1.179 g/L at 77 °F (25 °C)
Water Solubility: 1.6 mg/L at 59 °F (15 °C)
Other Solubilities: 1 g in: 2.4 mL toluene, 2.4 mL carbon tetrachloride, 2 mL benzene, 1 mL carbon disulfide, 25 mL absolute alcohol, 60 mL cold 95% alcohol, 10 mL boiling 95% alcohol and 3.3 mL anhydrous ether. Also soluble in glacial acetic acid, chloroform, and hot pyridine.
Boiling Point: 644 °F (340 °C)
Melting Point: 213 °F (101 °C)
Refraction Index: 1.59427
Octanol/Water Partition Coefficient: log Kow = 4.57

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Section 10 - Stability and Reactivity

Stability: Phenanthrene is stable at room temperature in closed containers under normal storage and handling conditions.
Polymerization: Hazardous polymerization does not occur.
Chemical Incompatibilities: Strong oxidizers.
Conditions to Avoid: Phenanthrene dust generation and exposure to heat ignition sources, or oxidizers.
Hazardous Decomposition Products: Thermal oxidative decomposition of phenanthrene can produce carbon oxide(s).

Section 11- Toxicological Information

Toxicity Data:*

Acute Oral Effects:
Mouse, oral, LD_{50}: 700 mg/kg

Carcinogenicity:
Mouse, skin: 71 mg/kg produced tumors at site of application.

Mutagenicity:
Rat, liver cell: 3 mmol/L caused DNA damage
Human, lymphocyte: 100 µmol/L caused mutation

* See NIOSH, *RTECS* (SF7175000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: *Neanhes arenaceodentata*, TLm = 0.6 ppm/96 hr, sea water at 71.6 °F (22 °C)
Environmental Degradation: If released to soil, some phenanthrene may biodegrade but the majority will bind to the soil without much leaching to groundwater. Volatilization is not expected to be significant. In water, it will adhere to particulates and sediment. Photolysis may occur near the surface producing toxic substances. Photolysis/photooxidation half-life = 8.4 hr. In the air, it will react with photochemically generated hydroxyl radicals (half-life = 1.67 days).
Soil Absorption/Mobility: Phenanthrene absorbs strongly to soil and sediment in water.

Section 13 - Disposal Considerations

Disposal: For treatment of phenanthrene contaminated water, the particulate bound portion can be removed by sedimentation, flocculation, and filtration. Chlorination is not recommended as it has been shown to produce mutagenic substances. The dissolved portion requires oxidation for partial removal. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name:
Environmentally hazardous substances, solid, n.o.s.*
Shipping Symbols: —
Hazard Class: 9
ID No.: UN3077
Packing Group: III
Label: Class 9
Special Provisions (172.102): 8, B54, N50

Packaging Authorizations
a) Exceptions: 173.155
b) Non-bulk Packaging: 173.213
c) Bulk Packaging: 173.240

Quantity Limitations
a) Passenger, Aircraft, or Railcar: None
b) Cargo Aircraft Only: None

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: —

* Classified as a hazardous substance when phenanthrene is in a quantity, in one package, which equals or exceeds the RQ of 5000 lb (2270 kg)

Section 15 - Regulatory Information

EPA Regulations:
RCRA Hazardous Waste Number: Not listed
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per CWA, Sec. 307(a)
CERCLA Reportable Quantity (RQ), 5000 lb (2270 kg)
SARA 311/312 Codes: 1
SARA Toxic Chemical (40 CFR 372.65): Not listed
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
OSHA Regulations:
Listed (coal tar pitch volatiles) as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 23, 73, 103, 124, 132, 133, 136, 139, 159, 164, 187, 190
Prepared By.....M Gannon, BA
Industrial Hygiene Review.....PA Roy, MPH, CIH

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Medical Review ..... W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 538
Ethyl Chloride
Issued: 5/85 Revision: A, 5/93

Section 1. Material Identification

Ethyl Chloride (CH_3CH_2Cl) Description: Derived by passing hydrogen chloride into a solution of zinc chloride and ethanol or by action of chlorine on ethylene in presence of chlorides of copper, iron, antimony, and calcium. Used in organic synthesis, refrigeration, manufacture of insecticides, ethyl cellulose, dyes, drugs, and perfumes; as an alkylating agent and analytical agent; solvent for fats, oils, waxes, phosphorus, acetylene, and many resins; propellant in aerosols; and formerly as an anesthetic (no longer used because of possible respiratory and circulatory depression).

Other Designations: CAS No. 75-00-3, Aethylis, Anodynon, Chloridium, chloroethane, chloryl anesthetic, hydrochloric ether, Kelene, monochloroethane, muriatic ether, Narcotile.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

R 1
I 2
S 2*
K 4
* Skin absorption

NFPA
4
2 0
–

HMIS
H 2
F 4
R 1
PPE†
† See 8

Cautions: Ethyl Chloride is a highly flammable and explosive gas. Inhalation of high concentrations can cause central nervous system depression. Skin absorption is possible and the liquid can cause frostbite.

Section 2. Ingredients and Occupational Exposure Limits

Ethyl Chloride, ca 100%

1992 OSHA PELs
Transitional & Final Rule Limits
8-hr TWA: 1000 ppm (2600 mg/m^3)

1993-94 ACGIH TLV*
TWA: 1000 ppm (2640 mg/m^3)

1992 Toxicity Data†
Rat, inhalation, LC_{50}: 160 g/m^3/2 hr; no toxic effects noted

1990 IDLH Level
20,000 ppm

1991 DFG (Germany) MAK
None established

1992 NIOSH REL
None established

* Notice of intended change to 100 ppm (264mg/m^3) and designation as a class A3 carcinogen (animal carcinogen).
†See NIOSH, *RTECS* (KH7525000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 54 °F (12 °C)
Freezing Point: -217.6 °F (-138.7 °C)
Vapor Pressure: 1064 mm Hg at 68 °F (20 °C)
Density (Air = 1): 2.22
Surface Tension: 19.5 dyne/cm at 68 °F (20 °C)
Ionization Potential: 10.97 eV
Relative Evaporation Rate (BuAc =1): > 1
Viscosity: 0.279 cP at 50 °F (10 °C)
Octanol/Water Partition Coefficient: log Kow = 1.43

Molecular Weight: 64.52
Specific Gravity: 0.9214 at 32 °F (0 °C)
Water Solubility: 0.57% at 68 °F (20 °C)
Other Solubilities: Per 100 g water at 77 °F (25 °C): acetone (103 g), benzene (110 g), *n*-heptane (87 g), methanol (37 g); at (21 °C): ethanol (48 g)
Odor Threshold: 4.2 ppm (should be sufficient warning)
Critical Pressure: 52 atm
Critical Temperature: 368.9 °F (187.2 °C)

Appearance and Odor: Colorless gas with an ethereal, slightly pungent odor at room temperature. When compressed, it is a colorless, volatile liquid.

Section 4. Fire and Explosion Data

Flash Point: -58 °F (-50 °C) CC	Autoignition Temperature: 966 °F (519 °C)	LEL: 3.8% v/v	UEL: 15.4% v/v

Extinguishing Media: For small fires, use dry chemical, water spray, or regular foam. For large fires, use water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: Burning rate = 3.8 mm/minute. Container may explode in heat of fire. Ethyl chloride presents a vapor explosion hazard indoors, outdoors, and in sewers. Burns with a smoky, greenish flame.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection. Apply cooling water to sides of containers until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Withdraw immediately in case you hear a rising sound from venting safety device or notice any tank discoloration due to fire. *Do not* release runoff from fire control methods to sewers or waterways; dike for proper disposal.

Section 5. Reactivity Data

Stability/Polymerization: Ethyl chloride is stable up to 752 °F (400 °C) in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Include oxidizing materials, water/steam (produces hydrogen chloride), sodium, potassium, calcium, and powdered aluminum, copper, magnesium, and zinc.
Conditions to Avoid: Contact with heat, ignition sources, and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of ethyl chloride can produce phosgene, and hydrogen chloride gas.

Section 6. Health Hazard Data

Carcinogenicity: The following agencies consider ethyl chloride to be a carcinogen: NIOSH-X(183) and DFG MAK-B.(183) The NTP has positive studies (equivocal tumorigenic agent) but no carcinogen designations have been assigned.
Summary of Risks: Ethyl chloride does not appear to present a serious industrial health hazard because very high concentrations are needed to produce adverse effects. If concentrations are high, central nervous system depression is the most common effect and...

Continue on next page

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Section 6. Health Hazard Data, *continued*

the resulting "drunkenness" and incoordination may lead to incorrect machinery operation with possible injury. Ethyl chloride can be absorbed through the skin and frostbite is possible from contact with the liquid (compressed gas).

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Target Organs: Respiratory and cardiovascular system; liver and kidneys (seen in animals and is possible but not likely in humans).

Primary Entry Routes: Inhalation, skin absorption.

Acute Effects: At high concentrations, inhalation can cause central nervous system depression and cardiac arrythmias. Some irritation of the eyes, skin, and respiratory tract is also possible. Allergic eczema is reported in two individuals subjected to an allergy test but it is not expected to occur frequently. Volunteers exposed to 40,000 ppm experienced dizziness, eye irritation, and abdominal cramps; 25,000 ppm caused incoordination; 19,000 produced analgesia after 12 minutes; and 13,000 ppm resulted in slight inebriation. Ethyl chloride is quickly absorbed both via the lungs and through the skin but most is eliminated via the lungs just as quickly.

Chronic Effects: None reported.

FIRST AID Eyes and Skin: The liquid (compressed gas) can cause frostbite. Immerse affected skin (or rinse eyes) with tepid water (104 °F/ 40 °C) until completely rewarmed. *Do not* rub affected area or use dry heat!

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Treatment is symptomatic and supportive.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Isolate and ventilate area, deny entry, and stay upwind. Stop gas flow. Shut off all ignition sources. Cleanup personnel should protect against gas inhalation and contact with the liquid. It is a gas above 54 °F (12 °C) so if spilled as a liquid, it would tend to evaporate before cleanup could begin. Prevent entry into sewers, drains, and waterways. Follow applicable OSHA regulations (29 CFR 1910.120).

Environmental Degradation: In water, some ethyl chloride will volatilize with estimated half-life of 1.1 to 5.6 days and some will hydrolyze with an estimated half-life of 38 days at 77 °F (25 °C). In soil, some will volatilize (dry soil) or leach; and some will hydrolyze (moist soil). In air, ethyl chloride will react with photochemically produced hydroxyl radicals with an estimated half-life of 40 days.

Soil Absorption/Mobility: With estimated Koc values of 33 and 143, ethyl chloride is expected to be highly mobile.

Disposal: Thermal destruction is difficult unless a gas feed to an incinerator (permit-approved facility only) can be arranged. Complete combustion is necessary to prevent the formation of phosgene gas. Incinerator should be equipped with an afterburner and scrubber to remove the halo-acids. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a RCRA Hazardous Waste (40 CFR 261.21): D001, "Characteristic of Ignitability"
Listed "chlorinated ethanes" as a CERCLA Hazardous Substance* (40 CFR 302.4); per CWA, Sec. 307 (a)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

* An RQ is not given for the broad class.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 10,000 ppm, use a supplied-air respirator (SAR) or SCBA. For < 20,000 ppm, use a SAR operated in continuous-flow mode or any SAR or SCBA with a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Other: Wear chemically protective gloves, boots, aprons, and gauntlets made of Viton, nitrile, or butyl rubber to prevent skin contact.

Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Separate work and street clothes and launder before reuse. Remove ethyl chloride from shoes and clean PPE.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using ethyl chloride, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage/Handling Requirements: Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles. Outside or detached storage is preferred. Inside storage should be in a standard flammable liquids storage cabinet.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Install Class I, Group D electrical equipment

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers. Educate workers on ethyl chloride's explosive potential.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Ethyl Chloride
DOT Hazard Class: 2.1
ID No.: UN1037
DOT Packing Group: —
DOT Label: Flammable Gas
Special Provisions (172.102): B63, B77

Packaging Authorizations
a) Exceptions: None
b) Non-bulk Packaging: 173.322
c) Bulk Packaging: 173.314, .315

Quantity Limitations
a) Passenger Aircraft or Railcar: Forbidden
b) Cargo Aircraft Only: 150 kg

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 148, 153, 159, 164, 167, 168, 176, 183, 186
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** TW Thoburn, MPH, MD

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Material Safety Data Sheet Collection

Lindane **MSDS No. 560**

Date of Preparation: 6/94

Section 1 - Chemical Product and Company Identification 44

Product/Chemical Name: Lindane
Chemical Formula: $C_6H_6Cl_6$
CAS No.: 58-89-9
Synonyms: Agrocide; Devoran; gamma-benzene hexachloride; gamma-BHC; gamma-HCH; 1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer; Kwell; Lentox; Novigam; Streunex
Derivation: Lindane is the gamma isomer of hexachlorocyclohexane, of which there are 4 others (alpha, beta, delta, epsilon). The gamma isomer is found to be the most effective. Produced by reaction of chlorine with excess benzene in the presence of sunlight to give isomeric mixtures, followed by treatment with methanol or acetic acid and then fractional crystallization or chromatographic adsorption to separate the gamma isomer. Lindane is available in emulsifiable concentrates, flowables, wettable powders, oil-base sprays, granules, dusts, or aerosols.
General Use: Lindane is an insecticide. It is used for control of insects on wood, cotton and other foliar plants; treatment of soil and vegetable/fruit seeds; control of termites; and medicinally (1% solutions) to kill lice and mites (scabies) on the human body.
Vendors: Consult the latest *Chemical Week Buyers' Guide*. (73)

Section 2 - Composition / Information on Ingredients

Lindane; the commercial grade (medicinal) contains 99+% gamma isomer (lindane), and the technical grade contains ~ 64% alpha, 10% beta, 13% gamma, 9% delta, and 1% epsilon.

OSHA PEL
8-hr TWA: 0.5 mg/m^3

ACGIH TLV
TWA: 0.5 mg/m^3 (skin)

NIOSH REL
10-hr TWA: 0.5 mg/m^3 (skin)

IDLH Level
1000 mg/m^3

DFG (Germany) MAK
TWA: 0.5 mg/m^3 (skin)
Category III: Substances with systemic effects
Onset of effect: > 2 hr
Half-life> shift length (strongly cumulative)

Peak Exposure Limit:
5 mg/m^3, 30 min. average value, 1/shift

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Lindane exists as a white to yellow crystalline solid with a slight musty odor. It exerts its toxicity primarily on the central nervous system resulting in convulsions and seizures. Inhalation may also cause irritation of the eyes, nose, and throat. Acute toxicity appears to be more prominent than chronic toxicity with this gamma isomer, whereas the other isomers of hexachlorocyclohexane appear to have primarily chronic effects. Lindane is readily absorbed through the skin, but ingestion has resulted in the severest symptoms.

Wilson Risk Scale
R 1
I 3
S 2*
K 0†
*Skin absorption

HMIS
H 3
F 0†
R 0

† If in solution, solvent may elevate the rating to 2.
PPE‡
‡Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin contact/absorption, ingestion.
Target Organs: Eyes, skin, central nervous system, respiratory tract, and possibly (as seen in animals) the liver, kidneys, and blood.
Acute Effects
Inhalation: Can cause irritation of the eyes, nose, and throat, severe headache, nausea and vomiting.
Eye: Irritation. Conjunctivitis can occur from application of 1% solution to eyelashes. Optic atrophy (tissue death) and blindness occurred in one patient with systemic toxicity.
Skin: Skin contact may cause sensitivity reactions. Lindane is easily absorbed through the skin, especially in hot, humid conditions. Systemic effects are similar to those via ingestion (see below). In one case of fatal skin absorption, the autopsy revealed cerebral edema (swelling of the brain), and hemorrhaging with localized tissue anemia of the kidney. Toxic levels absorbed through the skin may be a significant hazard with medicinal use, especially in children.
Ingestion: Toxicity appears to be most severe via ingestion. Toxicity generally occurs at doses > 50 mg (children) or >150 mg (adults). The estimated fatal dose is 600 mg/kg. Symptoms develop rapidly after ingestion of pure lindane and 2 to 12 hr after ingestion of the technical mixture. If fatal, death occurs within 24 hr. Symptoms include malaise, nausea and vomiting, dizziness, diarrhea, agitation, collapse, cyanosis, muscle tremors, violent convulsions, and seizures.
Carcinogenicity: Listed as a carcinogen by the following agencies: IARC (Class 2B), NTP (Class 2), and EPA (Class B2). Not listed as a carcinogen by OSHA. There have been four cases of leukemia in men exposed to lindane (with or without other chemicals).
Medical Conditions Aggravated by Long-Term Exposure: Seizure disorders, especially those treated with phenytoin.

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Chronic Effects: Lindane is suspected of causing aplastic or hypoplastic anemia in many individuals, but this is questionable since in 1/3 of 46 cases of reported bone marrow injury, there was also exposure to other agents including benzene. It is concluded that blood disorders are possible, but generally in hypersensitive individuals. Minor liver damage has been seen in animals but not yet documented in humans. One case of motor neuron disease has been reported from chronic exposure.

Other: Lindane is metabolized to 2,3,4,6-tetrachlorophenol. Its half-life in plasma is 26 hr (IV injection) and 18.2 hr (skin absorption). Lindane is stored in the fat at about the same rate as intake. Maximum storage is reached at 6 weeks and disappears after another 3 weeks. Of all the hexachlorocyclohexane isomers, gamma (lindane) is the least cumulative. Concurrent exposure to cadmium has been shown to inhibit lindane metabolism and increase toxicity and mutagenicity in animals.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.

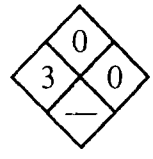
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water to dilute. The decision to induce vomiting should be made on an individual basis; use caution because of the high probability of seizures. Do not administer milk, fatty foods, or oils because they enhance absorption.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Lindane concentration in blood is an indication of extent of absorption. Symptoms (after ingestion/skin absorption of the technical mixture) may be delayed. Perform a CBC including rbc, wbc and differential. Precautions against seizures should be taken in cases of acute exposure.

Section 5 - Fire-Fighting Measures

Genium



Flash Point: Noncombustible. Lindane may be dissolved in a solvent [~ flash point = 150 °F (65.6 °C)].

Autoignition Temperature: Noncombustible.

LEL: None reported.

UEL: None reported.

Extinguishing Media: Use agent suitable for surrounding fire.

Unusual Fire or Explosion Hazards: Container may explode in heat of fire.

Hazardous Combustion Products: Carbon oxides, chlorine, hydrogen chloride, and phosgene gas.

Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways.

Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is *not* effective for protection against lindane. Wear chemical clothing specifically recommended by the shipper or manufacturer.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel should protect against inhalation and skin/eye contact.

Small Spills: Dampen material with alcohol to avoid dust generation. Carefully scoop into vapor-tight plastic bags and seal for later disposal. Dampen a paper towel with alcohol to wipe up any residue.

Large Spills

Containment: Dike far ahead of solution spill for later disposal. Do not release into sewers or waterways.

Cleanup: Wash spill area well with soap and water.

Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Avoid dust generation.

Storage Requirements: Store in a cool, dry, well-ventilated area away from alkalis and powdered aluminum iron, or zinc.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Enclose all processes where possible to avoid dust dispersion into work area.

Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103)

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the central nervous system, liver, kidneys, and blood.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For ≤ 5 mg/m^3, use any chemical cartridge respirator with a dust, mist, or fume filter, and protection against organic vapors; any supplied-air respirator (SAR); or any

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SCBA. For ≤ 12.5 mg/m^3, use any powered, air-purifying respirator with organic vapor cartridges and a dust, mist, and fume filter, or any SAR operated in continuous flow mode. For ≤ 25 mg/m^3, use any chemical cartridge respirator with a full facepiece, organic vapor cartridges, and a high-efficiency particulate filter; any SCBA or SAR with a full facepiece; any gas, mist, or fume respirator with organic vapor cartridges and a high efficiency particulate filter; or any powered, air purifying respirator with a tight fitting facepiece, organic vapor cartridges and a high-efficiency particulate filter. For ≤ 1000 mg/m^3, use any SAR operated in pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Polycarbonate and butyl rubber are suitable materials for PPE. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove lindane from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using lindane, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Solid

Appearance and Odor: White to yellow, crystalline solid with a slight, musty odor.

Vapor Pressure: 9.4 x 10^{-6} mm Hg at 68 °F (20 °C)

Formula Weight: 290.82

Specific Gravity (H_2O=1, at 4 °C): 1.85

Water Solubility: 0.001%

Octanol/Water Partition Coefficient: log Kow = 3.72

Relative Evaporation Rate: 1.5 x 10^{-4} m/hr

Other Solubilities: Soluble in xylene (24.7%), toluene (27.6%), petroleum ether (2.9%), ethyl acetate (35.7%), carbon tetrachloride (6.7%), cyclohexanone (36.7%), acetic acid (12.8%), dioxane (31.4%); lindane solubility per 100 g/solvent: acetone (43.5 g), benzene (28.9 g), chloroform (24 g), ether (20.8 g) and ethanol (6.4 g).

Boiling Point: 614 °F (323 °C)

Melting Point: 234.5 °F (112.5 °C)

Refractive Index: 1.644 at 68 °F (20 °C/D)

Section 10 - Stability and Reactivity

Stability: Lindane will slowly decompose at ordinary pH [50% at 72 °F (22 °C), pH 7: 191 days] and more rapidly under alkaline conditions (50% at 22 °C, pH 9: 11 hr).

Polymerization: Hazardous polymerization does not occur.

Chemical Incompatibilities: Lindane is decomposed by alkalis to form trichlorobenzenes and reacts with powdered aluminum, iron, and zinc.

Conditions to Avoid: Exposure to incompatibles.

Hazardous Decomposition Products: Thermal oxidative decomposition of lindane can produce carbon oxides, chlorine, hydrogen chloride, and phosgene gas.

Section 11- Toxicological Information

Toxicity Data:*

Acute Oral Effects:

Child, oral, TD_{Lo}: 180 mg/kg caused convulsions or effect on seizure threshold, difficulty breathing, and cyanosis (blue-tinged skin, lips and fingernails due to a decrease in oxygenated blood).

Rat, oral, LD_{50}: 76 mg/kg

Acute Dermal Toxicity:

Man, skin, TD_{Lo}: 20 mg/kg applied intermittently for 6 weeks caused visual field and cardiac changes.

Rat, skin, LD_{50}: 414 mg/kg

Carcinogenicity:

Mouse, oral: 14 g/kg administered continuously for 2 years produced liver tumors.

Mouse, oral: 25 g/kg administered continuously for 73 weeks produced lung and liver tumors.

Mutagenicity:

Rat, liver cell: 30 µmol/L caused DNA damage.

Human, fibroblast: 100 mg/kg caused mutation.

Reproductive Effects:

Woman, oral: 5 mg/kg taken during the 18th week of pregnancy resulted in fetal death.

* See NIOSH, *RTECS* (GV4900000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Coho salmon, LC_{50} = 23 µg/L/96 hr; mallard duck, oral, LD_{50} = > 2000 mg/kg; rainbow trout, LC_{50} = 27 µg/L/96 hr; fathead minnow, LC_{50} = 87 µg/L/96 hr.

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Environmental Degradation: Lindane is more persistent in dry, sandy soils than in moist soils. 50 to 90% of lindane applied to moist soil was lost in 6 hr and 6 days, respectively. Only 12% was lost from dry soil in 50 hr. In general, lindane applied to soil will mostly volatilize while some will slowly leach to groundwater. If released to water, lindane will mostly diffuse into sediment. If water is alkaline, hydrolysis may occur. Lindane will bioconcentrate in some aquatic organisms. In the atmosphere, lindane will react with hydroxyl radicals (half-life: 1.63 days). It will also be removed by rainfall and dry deposition. Average residence time in the atmosphere is 17 weeks.

Section 13 - Disposal Considerations

Disposal: Lindane is a potential candidate for liquid injection or rotary kiln incineration. Biodegradation should be investigated as lindane may be decomposed by sludge flora or blue-green algae. Chemical processes appear to be of little use, as degradation products may be even more harmful than lindane itself. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Organochlorine pesticides, solid, toxic, n.o.s.
Shipping Symbols: –
Hazard Class: 6.1
ID No.: UN2761
Packing Group: III
Label: Keep Away From Food
Special Provisions (172.102): –

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.213
c) Bulk Packaging: 173.240

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 100 kg
b) Cargo Aircraft Only: 200 kg

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U129
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); and CWA, Sec. 307(a)
CERCLA Reportable Quantity (RQ), 1 lb (0.454 kg)
SARA 311/312 Codes: 1, 2
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a SARA EHS (Extremely Hazardous Substance) (40 CFR 355), Threshold Planning Quantity (TPQ): 1,000/10,000 lb*
OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

*The lower TPQ applies to solids in powder form with a particle size of < 100 microns; in molten or solution form; or meets the NFPA rating of 2, 3, or 4 for reactivity. If the solid does not meet any of these criteria, the higher TPQ applies.

Section 16 - Other Information

References: 73, 103, 124, 132, 133, 136, 148, 153, 167, 168, 169, 176, 187, 190

Prepared By ..... M Gannon, BA
Industrial Hygiene Review ..... PA Roy, MPH, CIH
Medical Review ..... W Silverman, MD

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00005209
IDENTIFIER INFORMATION----------

Chemical Name : DIELDRIN
Synonym(s) : ALVIT; COMPOUND 497; DIELDREX; DIELDRIN;
DIELDRIN (DOT); DIELDRINE (French); DIELDRITE
; ENT 16,225; HEOD;
HEXACHLOROEPOXYOCTAHYDRO-endo,exo-DIMETHANONA
PHTHALENE; I LLOXOL; NCI-C00124; OCTALOX;
PANORAM D-31; QUINTOX;
1,2,3,4,10,10-HEXACHLORO-6,7-EPOXY-1,4,4A,5,6
,7,8,8A-OC
TAHYDRO-1,4-ENDO-EXO-5,8-DI-METHANONAPHTHALEN
E; 3,4,5,6,9,9-HEXACHLOR
O-1a,2,2a,3,6,6a,7,7a-OCTAHYDRO-2,7:3,6-DIMET
HANO; DIELDRIN
(HEXACHLOROEPOXYOCTAHYDRO-ENDO,EXO-DIMETHANON
APHTHALENE 85% AND RELATED COMPOUNDS 15%);
HEXACHLOROEPOXYOCTAHYDRO-ENDO,EXO-DIMETHANONA
PHTHALENE 85% AND RELATED COMPOUNDS 15% =
DIELDRIN; ENT-16225; SD 3417; D-31

CAS Registry Number : 60-57-1
RTECS Number : IO1750000
Molecular Formula : C12H8Cl6O
Molecular Weight : 380.91
Wisswesser Line Notation : T E3 D5 C555 A D- FO KUTJ AG AG BG JG KG LG
ENDO EXO
Record Last Updated : 03/09/95

PHYSICAL PROPERTY INFORMATION----------

Physical Description : WHITE CRYSTALS OR LIGHT BROWN FLAKES WITH A MILD CHEMTICAL ODOR. MAY BE DISSOLVED IN PETROLEUM BASED SOLVENT. (NYDH) [INSECTICIDE]

Boiling Point in F : dec
Boiling Point in K : dec
Melting Point in C : 174.3 C
Melting Point in F : 345.8 F
Melting Point in K : 447.51 K
Auto Ignition in C : -
Auto Ignition in F : -
Auto Ignition in K : ~
Flash Point in C : ~
Flash Point in F : ~
Flash Point in K : ~
Vapor Pressure (psi) : No data
Vapor Pressure Data : 1.8X10-7
Vapor Specific Gravity : No data
Evaporation Rate : Not given
Upper Explosive Limit : Not applicable
Lower Explosive Limit : Not applicable
Specific Gravity : 1.75 @ 20C
Water Solubility (mg/L) : 0.02 %
Absorbance Units : No data
Incompatibilities : STRONG OX,ACTIVE METALS LIKE SODIUM,STRONG ACIDS,PHENOLS
Reactivity w/ Water : No data on water reactivity
Reactivity w/ Common Mtl : No data
Stability During Transport : No Data
Polymerization Possibile : No data
Practical Quantitation : 0.05; 10
Toxic Fire Gases : None reported other than possible unburned vapors
Odor Description : Mild chemical
Odor (100% Pop. Detection) : No data
Odor Detection Lower Limit : 0.041 ppm
Uses : Insecticide. Condensed Chemical Dictionary, 10th ed.

General Storage Reqs : KEEP IN TIGHTLY SEALED CONTAINERS, PREFERABLY OUTDOORS.(NYDH)

REGULATORY INFORMATION----------

DOT - Department of Transportation
DOT Shipping Name : Dieldrin
DOT Identification Num. : NA2761
DOT Hazard Class : 6.1 POISON
DOT Guide Number : 55
DOT Label(s) Required : POISON
EPA Water - Environmental Protection Agency
Clean Water Act (CWA) : Sec 307 and 311
CWA Priority Pollutant : Yes
CWA Hazardous Sub Listed: Yes
MCL (Max Contam Level) : Not specified
MCLG (Max Contam Goal) : Not specified
Marine Pollutant List : Severe marine pollutant listed by name
EPA AIR - Environmental Protection Agency
Clean Air Act : Not listed
Air Sampling Agency : NIOSH; OSHA
Air Sampling Method : 3(S283); IMIS0905
NIOSH/OSHA Analytical Method: GC; GC/ECD
EPA SUPERFUND - Environmental Protection Agency
SARA 312 Categories
Acute toxicity: Toxic. LD50 > 50 and <= 500 mg/kg (oral rat).
Chronic toxicity: reproductive toxin.
Acute toxicity: Highly toxic. LD50 is 50 mg/kg or less (oral rat).
Chronic toxicity: carcinogen
CERCLA RQ Symbol : X CERCLA
CERCLA RQ (Rep. Qty) : 1 pound (0.454 kg) CERCLA
TPQ (Threshold Pl. Qty.): Not listed
USPS - US Postal Service
Hazard class: ORM-A
Mailability: Domestic service and air transportation; shipper's declaration required
Max per parcel: 70 LBS; 5 LBS
NFPA - National Fire Protection Association Code Information
Health Hazard (BLUE) : Unspecified
Flammability (RED) : Unspecified
Reactivity (YELLOW) : Unspecified
Special : Unspecified

OSHA - Occupational Safety & Health Administration
STEL : Not in Table Z-1-A
Exposure Comment : X
Exposure Limit Comment : SKIN
8 Hour Air Contam Limit : Final Rule Limits: TWA = 0.25 mg/M3(SKIN)
HS System ID : Not given
Air Contam Ceiling Limit: Not in Table Z-1-A
Duration at Max Conc : 0.25
EPA - Environmental Protection Agency
Waste Number : P037
Solid Waste Analyt Meth : 8080 8270
Toxic Characteristics ID: None
Pesticide Rereg Ingred : Not listed
TSCA Status
EPA TSCA Test Submission (TSCATS) Database - September 1989
EPA TSCA Test Submission (TSCATS) Database - April 1990
TSCA Rulemaking
Name :LIST OF HAZARDOUS SUBSTANCES UNDER 104(I) OF THE COMPREHENSIVE
ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA OR
SUPERFUND) AS AMENDED BY SARA SECTION 110.
40 CFR:
Final cite :52 FR 12866
Published :04/17/87
Notes :FIRST list of 100 hazardous substances.
State Regulatory Information
CA List of Lists
(B) EPA List of Priority Pollutants.
(C) AB 1803 Well Monitoring Chemicals.
(G) AB 2588 Air Toxics "Hot Spots" Chemicals.
(H) D.H.S. Drinking Water Action List.
(K) Prop. 65 Chemicals List.
MA List of Lists
DIELDRIN
OSHA
ACGIH
Carc Assessment Group (EPA)
NCI
Extraordinarily Hazardous Substance
Carcinogen
FEPA

NJ List of Lists
List number 0683
Carcinogen
Mutagen
NJ "Right To Know" Num. : 0683
NJ "Right To Know" Codes: CA,MU
PA List of Lists
Environmental Hazard
WA Hazard Designation : 0
Canadian Ingredients Disclosure List
Listed ? : N
OTHER
Threshhold Quantity (TQ): Not listed
Toxic Character Reg Lvl : Not given
STCC Number : 4941134 4941135 4941133

Summary of Regulatory Lists That This Substance Appears On

ACGIH TLV list "Threshold Limit Values for 1992-1993"
ATSDR Toxicology Profile available (NTIS**
California Assembly Bill 1803 Well Monitoring Chemicals.
California Assembly Bill 2588 Air Toxics "Hot Spots" Chemicals.
California Department of Health Services Drinking Water Action List.
Clean Water Act Section 307 Priority Pollutants
Clean Water Act Section 311 Hazardous Chemicals List.
DIELDRIN [60-57-1]
DOT Hazardous Materials Table. 49 CFR 172.101
EPA Carcinogen Assessment Group List
EPA TSCA Test Submission (TSCATS) Database - April 1990
EPA TSCA Test Submission (TSCATS) Database - September 1989
First Third Wastes List. 40 CFR 268.10. 54 FR 26594 (June 23, 1989)
Massachusetts Substance List.
New Jersey Right To Know Substance List. (December 1987)
New Jersey Right to Know Substance List. Listed as a carcinogen.
New Jersey Right to Know Substance List. Listed as a mutagen.
OSHA Air Contaminant (Table Z-1-A). 54 FR 4332, Jan. 19, 1989 and revised.
Pennsylvania Hazardous Substance List
RCRA Hazardous Constituents for Ground Water Monitoring. Ap'dx IX to 40
CFR 264
RCRA Hazardous Waste
SARA Section 110 Priority List of CERCLA Hazardous Substances

Superfund/CERCLA RQ list. Table 302.4 in 54 FR 50968 (December 11,
1989)
Washington State Discarded Chemical Products List, November 17, 1989

TOXICITY INFORMATION----------

Short Term Toxicity
Inhalation: MAY CAUSE NAUSEA, DROWSINESS, LOSS OF APPETITE, VISUAL
DISTURBANCES AND INSOMNIA. SPRAYS OF 1 TO 2 1/2% HAVE CAUSED
GIDDINESS, HEADACHE, MUSCLE TWITCHING, CONVULSIONS AND LOSS OF
CONSCIOUSNESS.
Skin: CAN BE ABSORBED TO CAUSE OR INCREASE THE SEVERITY OF SYMPTOMS AS
LISTED UNDER INGESTION.
Eyes: CAN CAUSE IRRITATION AND REDNESS.
Ingestion: MAY CAUSE HEADACHE, NAUSEA, INSOMNIA, HIGH BLOOD PRESSURE,
VISION PROBLEMS, LOSS OF COORDINATION, PROFUSE SWEATING, DIZZINESS,
FROTHING AT THE MOUTH, CONVULSIONS AND LOSS OF CONSCIOUSNESS. DEATH
MAY OCCUR FROM AS LITTLE AT 1/20 OUNCE (1.4 GRAM). SOME SYMPTOMS MAY
BE DELAYED UP TO 12 HOURS.(NYDH)
Long Term Toxicity
WORKPLACE RELATED EXPOSURE HAS CAUSED DIZZINESS, NAUSEA, MUSCLE TWITCH,
CONVULSIONS, ENLARGED LIVER AND SKIN IRRITATION. DIELDRIN HAS CAUSED
CANCER IN LABORATORY ANIMALS. IT IS CONSIDERED A SUSPECT OCCUPATIONAL
CARCINOGEN.(NYDH)
Symptoms : Inhalation, ingestion, or skin contact causes irritability, convulsions and/or coma, nausea, vomiting, headache, fainting, tremors. Contact with eyes causes irritation. CHRIS
NIOSH Immed. Danger Conc : 50 mg/m3
NIOSH REL
Potential occupational carcinogen

--LOWEST FEASIBLE
ACGIH Threshold Limit Value : TLV = 0.25mg/M3 SKIN
ACGIH Short Term Exposure Limit : Not listed
OSHA PEL
Transitional Limits:
PEL = 0.25mg/M3(SKIN)
Final Rule Limits:
TWA = 0.25 mg/M3(SKIN)
Carcinogen : N
RTECS Carcinogen Determ. : ANIMAL POSITIVE IARC** 5,125,74
HUMAN
INDEFINITE IARC** 5,125,74
Carcinogen Lists
IARC : 3 7009
MAK : No
NIOSH : Y
NTP : No
ACGIH : No
OSHA : No
Carcinogen List Summary
3 7009
MAK: Not listed
NIOSH: Carcinogen defined by NIOSH with no further categorization.
NTP: Not listed
ACGIH: Not listed
OSHA: Not listed
EPA CAGS Hazard Ranking : HIGH
LD50 Value : orl-rat LD50:38300 ug/ kg
LD50 Value (rat) : 38.3
LD50 Value (albino rabbit): 250
LC50 Value
ihl-rat LC50:13 mg/m3/4H 85GMAT -,73,82
ihl-cat LC50:80 mg/m3/4H GTPZAB 8(4),30,64
Human Toxic Effects
* orl-man LDLo:65 mg/kg 34ZIAG -,215,69
Human Toxicity Data
* orl-man LDLo:65 mg/kg 34ZIAG -,215,69
unr-hmn LDLo:28 mg/kg ATXKA8 22,115,66
Other Species Toxicity
* orl-rat LD50:38300 ug/kg JAFCAU 3,402,55
* ihl-rat LC50:13 mg/m3/4H 85GMAT -,73,82
* skn-rat LD50:56 mg/kg RPZHAW 18,161,67
* ipr-rat LD50:35 mg/kg CBPCEE 85,437,86

* scu-rat LD50:49 mg/kg 85GMAT -,73,82
* ivn-rat LD50:9 mg/kg BJIMAG 21,269,64
* orl-mus LD50:38 mg/kg SPEADM 78-1,13,78
* ipr-mus LDLo:26 mg/kg TXAPA9 23,288,72
* ivn-mus LD50:10500 ug/kg TXAPA9 23,408,72
* orl-dog LD50:65 mg/kg GUCHAZ 6,198,73
* unr-dog LDLo:65 mg/kg AMIHBC 3,64,51
* orl-mky LD50:3 mg/kg 32ZDAL -,79,70
3J16L03M30orl-cat LDLo:500 mg/kg CVETAA 2,71,58
3F07F12F13ihl-cat LC50:80 mg/m3/4H GTPZAB 8(4),30,64
3F15F31K13skn-cat LDLo:750 mg/kg CVETAA 2,71,58
* orl-rbt LD50:45 mg/kg PCOC** -,377,66
* skn-rbt LD50:250 mg/kg SPEADM 78-1,13,78
* scu-rbt LDLo:150 mg/kg 85GMAT -,73,82
* orl-pig LD50:38 mg/kg EJTXAZ 7,159,74
* orl-gpg LD50:49 mg/kg PCOC** -,377,66
* orl-ham LD50:60 mg/kg TJADAB 9,11,74
* orl-pgn LD50:23700 ug/kg ASTTA8 (680),157,79
* ivn-pgn LD50:1200 mg/kg 32ZDAL -,79,70
3D15F13F15orl-ckn LD50:20 mg/kg JEENAI 44,1013,51
3F05F07F33orl-qal LD50:10780 ug/kg ETOCDK 1,157,82
* orl-dck LD50:381 mg/kg TXAPA9 20,57,71
* unr-mam LD50:25 mg/kg 30ZDA9 -,63,71
* orl-bwd LD50:13300 ug/kg ASTTA8 (680),157,79

Reproductive Toxicity

orl-rat TDLo:14 ug/kg (multigenerations) PCBPBS 13,20,80

EFFECTS ON NEWBORN

Behavioral

orl-rat TDLo:336 ug/kg (56D male) 32OAAP -,189,73

PATERNAL EFFECTS

Prostate,seminal vessel,Cowper's gland,accessory glands,urethra

orl-mus TDLo:30600 ug/kg (6-14D preg) THERAP 25,907,70

SPECIFIC DEVELOPMENTAL ABNORMALITIES

Central nervous system

SPECIFIC DEVELOPMENTAL ABNORMALITIES

Eye,ear

orl-mus TDLo:15 mg/kg (9D preg) TJADAB 9,11,74

SPECIFIC DEVELOPMENTAL ABNORMALITIES

Craniofacial(including nose and tongue)
orl-mus TDLo:2250 ug/kg (6-14D preg) TJADAB 16,57,77

EFFECTS ON EMBRYO OR FETUS
Fetotoxicity(except death,e.g.,stunted fetus)
orl-mus TDLo:12500 ug/kg (1D male) FCTXAV 13,317,75

EFFECTS ON FERTILITY
Pre-implantation mortility
orl-mus TDLo:4500 ug/kg (6-14D preg) TJADAB 16,57,77

SPECIFIC DEVELOPMENTAL ABNORMALITIES
Musculoskeletal system
orl-mus TDLo:6250 ug/kg (5D male) ENVRAL 9,26,75

PATERNAL EFFECTS
Other effects on male
orl-dog TDLo:219 mg/kg (44W pre/1-8W preg) JAVMA4 123,28,53

EFFECTS ON NEWBORN
Live birth index(# fetuses per liter)
orl-ham TDLo:30 mg/kg (8D preg) TJADAB 9,11,74

EFFECTS ON FERTILITY
Post-implantation mortality
EFFECTS ON EMBRYO OR FETUS
Fetotoxicity(except death,e.g.,stunted fetus)

EFFECTS ON EMBRYO OR FETUS
Fetal death
orl-ham TDLo:30 mg/kg (8D preg) TJADAB 9,11,74

SPECIFIC DEVELOPMENTAL ABNORMALITIES
Eye,ear

SPECIFIC DEVELOPMENTAL ABNORMALITIES
Body wall

SPECIFIC DEVELOPMENTAL ABNORMALITIES
Craniofacial(including nose and tongue)
Toxicity Data (RTECS)
* orl-man LDLo:65 mg/kg 34ZIAG -,215,69
unr-hmn LDLo:28 mg/kg ATXKA8 22,115,66

* orl-rat LD50:38300 ug/kg JAFCAU 3,402,55
* ihl-rat LC50:13 mg/m3/4H 85GMAT -,73,82
* skn-rat LD50:56 mg/kg RPZHAW 18,161,67
* ipr-rat LD50:35 mg/kg CBPCEE 85,437,86
* scu-rat LD50:49 mg/kg 85GMAT -,73,82
* ivn-rat LD50:9 mg/kg BJIMAG 21,269,64
* orl-mus LD50:38 mg/kg SPEADM 78-1,13,78
* ipr-mus LDLo:26 mg/kg TXAPA9 23,288,72
* ivn-mus LD50:10500 ug/kg TXAPA9 23,408,72
* orl-dog LD50:65 mg/kg GUCHAZ 6,198,73
* unr-dog LDLo:65 mg/kg AMIHBC 3,64,51
* orl-mky LD50:3 mg/kg 32ZDAL -,79,70
orl-cat LDLo:500 mg/kg CVETAA 2,71,58
LUNGS, THORAX, OR RESPIRATION
Chronic pulmonary edema or congestion
LIVER
Fatty liver degeneration
KIDNEY,URETER,BLADDER
Other changes
ihl-cat LC50:80 mg/m3/4H GTPZAB 8(4),30,64
BEHAVIORAL
Somnolence(general depressed activity)
BEHAVIORAL
Convulsions or effect on seizure threshold
BEHAVIORAL
Excitement
skn-cat LDLo:750 mg/kg CVETAA 2,71,58
BEHAVIORAL
Food intake(animal)
BEHAVIORAL
Withdrawal
GASTROINTESTINAL
Nausea or vomiting
* orl-rbt LD50:45 mg/kg PCOC** -,377,66
* skn-rbt LD50:250 mg/kg SPEADM 78-1,13,78
* scu-rbt LDLo:150 mg/kg 85GMAT -,73,82
* orl-pig LD50:38 mg/kg EJTXAZ 7,159,74
* orl-gpg LD50:49 mg/kg PCOC** -,377,66
* orl-ham LD50:60 mg/kg TJADAB 9,11,74
* orl-pgn LD50:23700 ug/kg ASTTA8 (680),157,79
* ivn-pgn LD50:1200 mg/kg 32ZDAL -,79,70
orl-ckn LD50:20 mg/kg JEENAI 44,1013,51
SENSE ORGANS

Eye
Miosis(pupillary constriction)
BEHAVIORAL
Excitement
BEHAVIORAL
Food intake(animal)
orl-qal LD50:10780 ug/kg ETOCDK 1,157,82
BEHAVIORAL
Altered sleep time(including change in righting reflex)
BEHAVIORAL
Somnolence(general depressed activity)
BEHAVIORAL

* orl-dck LD50:381 mg/kg TXAPA9 20,57,71
* unr-mam LD50:25 mg/kg 30ZDA9 -,63,71

Irritation Data (RTECS)
No data

Reproductive Toxicology
orl-rat TDLo:14 ug/kg (multigenerations) PCBPBS 13,20,80
REPRODUCTIVE EFFECTS CODES
EFFECTS ON NEWBORN
Behavioral
orl-rat TDLo:336 ug/kg (56D male) 32OAAP -,189,73
REPRODUCTIVE EFFECTS CODES
PATERNAL EFFECTS
Prostate,seminal vessel,Cowper's gland,accessory glands,urethra
orl-mus TDLo:30600 ug/kg (6-14D preg) THERAP 25,907,70
REPRODUCTIVE EFFECTS CODES
SPECIFIC DEVELOPMENTAL ABNORMALITIES
Central nervous system
REPRODUCTIVE EFFECTS CODES
SPECIFIC DEVELOPMENTAL ABNORMALITIES
Eye,ear
orl-mus TDLo:15 mg/kg (9D preg) TJADAB 9,11,74
REPRODUCTIVE EFFECTS CODES
SPECIFIC DEVELOPMENTAL ABNORMALITIES
Craniofacial(including nose and tongue)
orl-mus TDLo:2250 ug/kg (6-14D preg) TJADAB 16,57,77
REPRODUCTIVE EFFECTS CODES
EFFECTS ON EMBRYO OR FETUS
Fetotoxicity(except death,e.g.,stunted fetus)
orl-mus TDLo:12500 ug/kg (1D male) FCTXAV 13,317,75
REPRODUCTIVE EFFECTS CODES

EFFECTS ON FERTILITY
Pre-implantation mortility
orl-mus TDLo:4500 ug/kg (6-14D preg) TJADAB 16,57,77
REPRODUCTIVE EFFECTS CODES
SPECIFIC DEVELOPMENTAL ABNORMALITIES
Musculoskeletal system
orl-mus TDLo:6250 ug/kg (5D male) ENVRAL 9,26,75
REPRODUCTIVE EFFECTS CODES
PATERNAL EFFECTS
Other effects on male
orl-dog TDLo:219 mg/kg (44W pre/1-8W preg) JAVMA4 123,28,53
REPRODUCTIVE EFFECTS CODES
EFFECTS ON NEWBORN
Live birth index(# fetuses per liter)
orl-ham TDLo:30 mg/kg (8D preg) TJADAB 9,11,74
REPRODUCTIVE EFFECTS CODES
EFFECTS ON FERTILITY
Post-implantation mortality
REPRODUCTIVE EFFECTS CODES
EFFECTS ON EMBRYO OR FETUS
Fetotoxicity(except death,e.g.,stunted fetus)
REPRODUCTIVE EFFECTS CODES
EFFECTS ON EMBRYO OR FETUS
Fetal death
orl-ham TDLo:30 mg/kg (8D preg) TJADAB 9,11,74
REPRODUCTIVE EFFECTS CODES
SPECIFIC DEVELOPMENTAL ABNORMALITIES
Eye,ear
REPRODUCTIVE EFFECTS CODES
SPECIFIC DEVELOPMENTAL ABNORMALITIES
Body wall
REPRODUCTIVE EFFECTS CODES
SPECIFIC DEVELOPMENTAL ABNORMALITIES
Craniofacial(including nose and tongue)

Mutagenic Data : Not listed in RTECS 1992

Routes of Entry : INGESTION, SKIN, INHALATION ** Source: CSDS

From Deutsche Forschungsgemeinshaft Reports

MAK Information

MAK workplace concentration data:
0.25 calculated as total dust mG/M3
Substance with systemic effects, onset of effect over 2 hours: Peak = 10xMAK for 30 minutes, once per shift of 8 hours.

Danger of cutaneous absorption
Teratogenic Data Group : MAK workplace concentration data Not listed
Carcinogenic Data Group : MAK workplace concentration data Not listed
Abnormal Sensitivity : MAK data Danger of cutaneous absorption
Max Workplace Conc. : 0.25 calculated as total dust
Exposure Peak Limits : MAK data Substance with systemic effects, onset of effect over 2 hours: Peak = 10xMAK for 30 minutes, once per shift of 8 hours.

FIRST AID AND PERSONAL PROTECTION INFO----------

First Aid
CHEMICAL: DIELDRIN
SOURCE: CHRIS Manual 1991
INHALATION: move to fresh air; give oxygen and artificial respiration as required.
INGESTION: induce vomiting and get medical attention.
EYES: flush with plenty of water; get medical attention.
SKIN: flush with plenty of water.
SOURCE: DOT Emergency Response Guide 1990.
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen. In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes. Speed in removing material from skin is of extreme importance. Removal of solidified molten material from skin requires medical assistance. Remove and isolate contaminated clothing and shoes at the site. Keep victim quiet and maintain normal body temperature. Effects may be delayed; keep victim under observation.
Protection Suggested
ACGIH Protect Guidelines: DIELDRIN ********** Butyl CPE Nat.
rubber Neoprene Nitrile Nitrile/PVC PE Polyurethane PVA PVC SBR
VITON
ACGIH Exposure Comments : SKIN
Med Conditions Aggrav. : Unknown
NIOSH Respirator Selection Info
NIOSH (DIELDRIN)
Greater at any detectable concentration. : Any self-contained breathing apparatus with full facepiece and operated in a

pressure-demand or other positive pressure mode. / Any supplied-air respirator with a full facepiece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

ESCAPE: Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister having a high-efficiency particulate filter. / Any appropriate escape-type self-contained breathing apparatus.

SPILL, STORAGE, AND INITIAL INCIDENT RESPONSE INFORMATION----------

DOT Shipping Name : Dieldrin
DOT ID Number : NA2761
DOT Hazard Class : 6.1 POISON
DOT Guide Information
DOT SHIPPING NAME: Dieldrin
DOT ID NUMBER: NA2761

ERG93 GUIDE 55
POTENTIAL HAZARDS
*HEALTH HAZARDS
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may give off poisonous gases and
cause water pollution.
Fire may produce irritating or poisonous gases.
*FIRE OR EXPLOSION
Some of these materials may burn, but none of them ignites readily.
Container may explode violently in heat of fire.
Material may be transported in a molten form.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry. Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
*Structural firefighters' protective clothing is not effective for these materials. See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action. Remove and isolate

contaminated clothing at the site. CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, CALL CHEMTREC AT 1-800-424-9300.
*FIRE
Small Fires: Dry chemical, water spray or regular foam.
Large Fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Fight fire from maximum distance. Stay away from ends of tanks.
Dike fire control water for later disposal; do not scatter the material.
*SPILL OR LEAK
Do not touch or walk through spilled material; stop leak if you can do it without risk. Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire. Use water spray to reduce vapors.
Small Spills: Take up with sand or other noncombustible absorbent material
and place into containers for later disposal. Small Dry Spills: With clean
shovel place material into clean, dry container and cover loosely; move

containers from spill area.
Large Spills: Dike far ahead of liquid spill for later disposal.
*FIRST AID
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen. In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes. Speed in removing material from skin is of extreme importance. Removal of solidified molten material from skin requires medical assistance. Remove and isolate contaminated clothing and shoes at the site. Keep victim quiet and maintain normal body temperature. Effects may be delayed; keep victim under observation.
Initial Isolation Distance: Not given
Small Spills : DAMPEN SPILLED MATERIAL WITH ALCOHOL TO AVOID
DUST, THEN TRANSFER MATERIAL TO A SUITABLE CONTAINER. USE ABSORBENT
PAPER DAMPENED WITH ALCOHOL TO PICK UP REMAINING MATERIAL, WASH
SURFACES WELL WITH SOAP AND WATER. SEAL ALL WASTES IN VAPOR-TIGHT
PLASTIC BAGS FOR EVENTUAL DISPOSAL. CSDS

1/5/2
DIALOG(R)File 337:CHEMTOX(R)
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00002934
IDENTIFIER INFORMATION----------

Chemical Name : 2,4,7-METHENO-1H-
CYCLOPENTA(a)PENTALENE,
1,1,2,3,3a,7a-HEXACHLORO-5,6-EPOXYDECAHYDRO-,stereoisomer
Synonym(s) : DIELDRIN, PHOTO-; NCI-C00599;
PHOTODIELDRIN
CAS Registry Number : 13366-73-9
RTECS Number : PC8800000
Molecular Formula : C12H8Cl6O
Molecular Weight : 380.90
Chemical Class : M
Wisswesser Line Notation : T E3 C5 B556 I5/DM A K 4BCJL M FOTJ
AG BG JG
KG KG LG
Record Last Updated : 03/09/95

PHYSICAL PROPERTY INFORMATION----------

Auto Ignition in C : -
Auto Ignition in F : -
Auto Ignition in K : ~
Flash Point in C : ~
Flash Point in F : ~
Flash Point in K : ~
Vapor Pressure (psi) : No data
Vapor Specific Gravity : No data
Evaporation Rate : Not given
Upper Explosive Limit : ~
Lower Explosive Limit : ~
Absorbance Units : No data
Reactivity w/ Water : No data on water reactivity
Reactivity w/ Common Mtl : No data
Stability During Transport : No Data
Polymerization Possibile : No data
Toxic Fire Gases : None reported other than possible unburned
vapors

Odor Description : No desc given
Odor (100% Pop. Detection) : No data
Odor Detection Lower Limit : No data
Uses : Not listed

REGULATORY INFORMATION----------

DOT - Department of Transportation
DOT Hazard Class : Not given
DOT Label(s) Required : Not given
EPA Water - Environmental Protection Agency
Clean Water Act (CWA) : Not covered
CWA Priority Pollutant : No
CWA Hazardous Sub Listed: No
MCL (Max Contam Level) : Not specified
MCLG (Max Contam Goal) : Not specified
Marine Pollutant List : Not listed
EPA AIR - Environmental Protection Agency
Clean Air Act : Not listed
EPA SUPERFUND - Environmental Protection Agency
SARA 312 Categories
No category
CERCLA RQ Symbol : Not listed
CERCLA RQ (Rep. Qty) : Not listed
TPQ (Threshold Pl. Qty.): Not listed
USPS - US Postal Service
Not given
NFPA - National Fire Protection Association Code Information
Health Hazard (BLUE) : Unspecified
Flammability (RED) : Unspecified
Reactivity (YELLOW) : Unspecified
Special : Unspecified
OSHA - Occupational Safety & Health Administration
STEL : Not in Table Z-1-A
8 Hour Air Contam Limit : Not in Table Z-1-A
HS System ID : Not given
Air Contam Ceiling Limit: Not in Table Z-1-A
EPA - Environmental Protection Agency
Toxic Characteristics ID: None
Pesticide Rereg Ingred : Not listed
TSCA Status
Not listed
State Regulatory Information

CA List of Lists
Not listed
CA Water List Cat & Date: Not listed
NJ List of Lists
Not listed
WA Hazard Designation : NA
Canadian Ingredients Disclosure List
Listed ? : N
OTHER
Threshhold Quantity (TQ): Not listed
Toxic Character Reg Lvl : Not given
Summary of Regulatory Lists That This Substance Appears On

2,4,7-METHENO-1H-CYCLOPENTA(a)PENTALENE,
1,1,2,3,3a,7a-HEXACHLORO-5,6-EPOXYDECAHYDRO-,stereoisomer
[13366-73-9]

TOXICITY INFORMATION----------

Short Term Toxicity
Unknown
Long Term Toxicity
Unknown
NIOSH REL
Not given
ACGIH Threshold Limit Value : Not listed
ACGIH Short Term Exposure Limit : Not listed
OSHA PEL
Not in Table Z-1-A
Carcinogen : N
Carcinogen Lists
IARC : No
MAK : No
NTP : No
ACGIH : No
OSHA : No
Carcinogen List Summary
IARC: Not listed
MAK: Not listed
NIOSH: Not listed
NTP: Not listed
ACGIH: Not listed
OSHA: Not listed

EPA CAGS Hazard Ranking : Not listed
LD50 Value : No LD50 in RTECS 1992
LD50 Value (albino rabbit): Not given
LC50 Value
No data in RTECS 1992
Reproductive Toxicity
Not given
Irritation Data (RTECS)
No data
Mutagenic Data : bacteria
Routes of Entry : Unknown
From Deutsche Forschungsgemeinshaft Reports
MAK Information
MAK workplace concentration data:
Not listed
Teratogenic Data Group : MAK workplace concentration data Not listed
Carcinogenic Data Group : MAK workplace concentration data Not listed
Abnormal Sensitivity : MAK data Not listed
Exposure Peak Limits : MAK data Not listed

FIRST AID AND PERSONAL PROTECTION INFO----------

Protection Suggested
ACGIH Protect Guidelines: 2,4,7-METHENO-1H-CYCLOPENTA(a)PENTALENE,
1,1,2,3,3a,7a-HEXACHLORO-5,6-EPOXYDECAHYDRO-,stereoisomer
****
***** Butyl CPE Nat. rubber Neoprene Nitrile Nitrile/PVC PE Polyurethane PVA PVC SBR VITON
Med Conditions Aggrav. : Unknown

SPILL, STORAGE, AND INITIAL INCIDENT RESPONSE INFORMATION----------
DOT Hazard Class : Not given
DOT Guide Information
DOT SHIPPING NAME:
DOT ID NUMBER:
No guide information for this compound.
Initial Isolation Distance: Not given
Extinguishing Media : Not given

DISCLAIMER: The data shown above on this chemical represents a best effort on the part of the compilers of the CHEMTOX database to obtain useful, accurate, and factual data. The use of these data shall be in accordance with the guidelines and limitations of the user's CHEMTOX license agreement.
The COMPILERS of the CHEMTOX database shall not be held liable for inaccuracies or omissions within this database, or in any of its printed or displayed output forms

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00010275
IDENTIFIER INFORMATION----------

Chemical Name : METHOXYCHLOR
Synonym(s) : 2,2-BIS(p-ANISYL)-1,1,1-
TRICHLOROETHANE;
1,1-BIS(p-METHOXYPHENYL)-2,2
,2-TRICHLOROETHANE;
2,2-BIS(p-METHOXYPHENYL)-1,1,1-
TRICHLOROETHAN
E; CH EMFORM;
2,2-DI-p-ANISYL-1,1,1-TRICHLOROETHANE;
DIMETHOXY-DDT; p,p'-DIME
THOXYDIPHENYLTRICHLOROETHANE;
DIMETHOXY-DT;
2,2-DI-(p-METHOXYPHENYL)-1
,1,1-TRICHLOROETHANE;
DI(p-METHOXYPHENYL)-TRICHLOROMETHYL
METHANE;
DMDT; p,p'-DMDT; ENT 1,716; ETHANE,
2,2-BIS(p-ANISYL)-1,1,1-TRICHLORO-;
MARALATE;
MARLATE; METHOXCIDE; METHO XO;
METHOXYCHLOR;
p,p'-METHOXYCHLOR; METHOXY-DDT;
METOKSYCHLOR
(Polish); METOX; MOXIE; NCI-C00497;
1,1,1-TRICHLORO-2,2-BIS(p-ANISYL)ETH ANE;
1,1'-(2,2,2-TRICHLOROETHYLIDENE)BIS(4-
METHOXY
BENZENE); 1,1,1-TRIC
HLORO-2,2-BIS(p-METHOXYPHENOL)ETHANOL;
1,1,1-TRICHLORO-2,2-BIS(p-METH
OXYPHENYL)ETHANE;
1,1,1-TRICHLORO-2,2-DI(4-
METHOXYPHENYL)ETHANE
; ETHAN E,
1,1,1-TRICHLORO-2,2-BIS(P-
METHOXYPHENYL);

2,2-BIS(P-METHOXYPHENYL)-1,
1,1-TRICHLOROETHANE

CAS Registry Number : 72-43-5
RTECS Number : KJ3675000
Molecular Formula : C16H15Cl3O2
Molecular Weight : 345.7
Wisswesser Line Notation : GXGGYR DO1
Record Last Updated : 03/09/95

PHYSICAL PROPERTY INFORMATION----------

Physical Description : WHITE, GREY OR PALE YELLOW CRYSTALS OR POWDER
WITH A SLIGHT, FRUITY ODOR. MAY BE DISSOLVED IN AN ORGANIC OR PETROLEUM
DISTILLATE SOLVENT FOR APPLICATION.(NYDH)
Boiling Point in F : dec
Boiling Point in K : dec
Melting Point in C : 77 C
Melting Point in F : 170.6 F
Melting Point in K : 350.16 K
Auto Ignition in C : -
Auto Ignition in F : -
Auto Ignition in K : ~
Flash Point in C : ~
Flash Point in F : ~
Flash Point in K : ~
Vapor Pressure (psi) : No data
Vapor Pressure Data : VERY LOW
Vapor Specific Gravity : No data
Evaporation Rate : Not given
Upper Explosive Limit : N.A.
Lower Explosive Limit : N.A.
Specific Gravity : 1.41 @ 25C
Water Solubility (mg/L) : :.01%
Absorbance Units : No data
Incompatibilities : STRONG OXIDIZERS
Reactivity w/ Water : No data on water reactivity
Reactivity w/ Common Mtl : No data
Stability During Transport : No Data
Polymerization Possibile : No data
Practical Quantitation : 2; 10
Toxic Fire Gases : None reported other than possible unburned

vapors
Odor Description : Slighty fruity
Odor (100% Pop. Detection) : No data
Odor Detection Lower Limit : Not pertinent
Uses : Insecticide effective against mosquito larvae and house flies. Especially recommended for use in dairy barns. Condensed Chemical Dictionary, 10th ed.
General Storage Reqs : PROTECT CONTAINERS FROM DAMAGE. STORE IN COOL, DRY AREA AWAY FROM FIRE HAZARD AND OUT OF DIRECT SUNLIGHT.(NYDH)

REGULATORY INFORMATION----------

DOT - Department of Transportation
DOT Shipping Name : ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. (METHOXYCHLOR)
DOT Identification Num. : UN3077
DOT Hazard Class : 9 CLASS 9
DOT Guide Number : 31
DOT Label(s) Required : CLASS 9
EPA Water - Environmental Protection Agency
Clean Water Act (CWA) : Sec 311
CWA Priority Pollutant : No
CWA Hazardous Sub Listed: Yes
MCL (Max Contam Level) : 0.04 mg/L (07/30/92)
MCLG (Max Contam Goal) : 0.04 mg/L (07/30/92)
Marine Pollutant List : Not listed
EPA AIR - Environmental Protection Agency
Clean Air Act : CAA '90 Listed
Air Sampling Agency : NIOSH; OSHA
Air Sampling Method : 4(S371); IMIS1646
NIOSH/OSHA Analytical Method: GC/ECD; GC/ECD
EPA SUPERFUND - Environmental Protection Agency
SARA 312 Categories
Chronic toxicity: mutagen.
Chronic toxicity: reproductive toxin.
Chronic toxicity: carcinogen
SARA 313 Reporting Reqs : 1.0
SARA Date : 6941
CERCLA RQ Symbol : X CERCLA
CERCLA RQ (Rep. Qty) : 1 pound (0.454 kg) CERCLA

TPQ (Threshold Pl. Qty.): Not listed
USPS - US Postal Service
Not given
NFPA - National Fire Protection Association Code Information
Health Hazard (BLUE) : Unspecified
Flammability (RED) : Unspecified
Reactivity (YELLOW) : Unspecified
Special : Unspecified
OSHA - Occupational Safety & Health Administration
STEL : Not in Table Z-1-A
8 Hour Air Contam Limit : Final Rule Limits: TWA = Total dust 10 mg/M3
HS System ID : 1246
Air Contam Ceiling Limit: Not in Table Z-1-A
Duration at Max Conc : Total dust 10
EPA - Environmental Protection Agency
Waste Number : U247 D014
Solid Waste Analyt Meth : 8080 8270
Toxic Characteristics ID: D014
Pesticide Rereg Ingred : Not listed
TSCA Status
EPA TSCA Test Submission (TSCATS) Database - September 1989
State Regulatory Information
CA List of Lists
(C) AB 1803 Well Monitoring Chemicals.
(D) SARA Section 313 Toxic Chemicals.
CA Water List Cat & Date: Not listed
MA List of Lists
MARLATE
OSHA
ACGIH
FEPA
FNCI
MD/NJ List of Chemicals ("X" = Yes)
x
NJ List of Lists
List number 1210
NJ "Right To Know" Num. : 1210
PA List of Lists
Environmental Hazard
WA Hazard Designation : 0
Canadian Ingredients Disclosure List
Listed ? : N

OTHER
Threshhold Quantity (TQ): Not listed
Toxic Character Reg Lvl : 10.0
STCC Number : 4960646 4960647 4960648

Summary of Regulatory Lists That This Substance Appears On

ACGIH TLV list "Threshold Limit Values for 1992-1993"
California Assembly Bill 1803 Well Monitoring Chemicals.
Clean Air Act of November 15, 1990. List of pollutants.
Clean Water Act Section 311 Hazardous Chemicals List.
DOT Hazardous Materials Table. 49 CFR 172.101
EPA TSCA Test Submission (TSCATS) Database - September 1989
METHOXYCHLOR [72-43-5]
Massachusetts Substance List.
New Jersey DEQ100 list for release reporting.
New Jersey Right To Know Substance List. (December 1987)
OSHA Air Contaminant (Table Z-1-A). 54 FR 4332, Jan. 19, 1989 and revised.
Pennsylvania Hazardous Substance List
RCRA Hazardous Constituents for Ground Water Monitoring. Ap'dx IX to 40
CFR 264
RCRA Hazardous Waste
RCRA Toxicity Characteristics (TC) list dated March 29, 1990
SARA Section 110 Priority List of CERCLA Hazardous Substances
SARA Section 313 Toxic Chemicals List
Superfund/CERCLA RQ list. Table 302.4 in 54 FR 50968 (December 11,
1989)
Third Third Wastes List. 40 CFR 268.12. 54 FR 26594 (June 23, 1989)
Washington State Discarded Chemical Products List, November 17, 1989

TOXICITY INFORMATION----------

Short Term Toxicity
Inhalation: THE RESULTS OF ACCIDENTAL EXPOSURE AND ANIMAL STUDIES
SUGGEST THAT HIGH LEVELS MAY CAUSE IRRITATION TO NOSE AND THROAT,
HEADACHE, NAUSEA, VOMITING, STAGGERING WALK, DROWSINESS, CONVULSIONS,

COMA AND DEATH.
Skin: ABSORBED IN SIGNIFICANT AMOUNTS ESPECIALLY WHEN DISSOLVED IN
ORGANIC SOLVENTS. LOCAL IRRITATION AND NUMBING OF AFFECTED AREA MAY
BE EXPERIENCED.
Eyes: MAY CAUSE IRRITATION.
Ingestion: SYMPTOMS ARE SIMILAR TO THOSE LISTED UNDER INHALATION.
INGESTION OF 5 OUNCES A DAY FOR 6 WEEKS RESULTED IN NO OBSERVABLE
SYMPTOMS. THE LEAST AMOUNT CAUSING DEATH HAS BEEN REPORTED AS ONE
POUND.(NYDH)
Long Term Toxicity
EXPERIMENTS WITH ANIMALS SUGGEST THAT EXPOSURE TO HIGH LEVELS FOR
PROLONGED PERIODS MAY CAUSE EXCESS SALIVATION, TREMORS, SEIZURES AND
CONVULSIONS. THESE WILL GENERALLY GO AWAY WHEN EXPOSURE STOPS.
METHOXYCHLOR HAS BEEN SHOWN TO AFFECT REPRODUCTION AND TO CAUSE CANCER
AT HIGH EXPOSURE LEVELS IN SOME LABORATORY ANIMALS. WHETHER IT DOES SO
IN HUMANS IS NOT KNOWN.(NYDH)
Target Organs : NONE KNOWN
Symptoms : Toxicity is relatively low. Inhalation or ingestion causes generalized depression. CHRIS
NIOSH Immed. Danger Conc : 5000 MG/M3
NIOSH REL
Potential occupational carcinogen
ACGIH Threshold Limit Value : TLV = 10mg/M3
ACGIH Short Term Exposure Limit : Not listed
OSHA PEL
Transitional Limits:
PEL = Total dust 15mg/M3
Final Rule Limits:
TWA = Total dust 10 mg/M3
Carcinogen : N
RTECS Carcinogen Determ. : NEGATIVE IARC** 20,259,79 ANIMAL INDEFINITE
IARC** 5,193,74

Carcinogen Lists
IARC : 3 7009
MAK : No
NIOSH : Y
NTP : No
ACGIH : No
OSHA : No
Carcinogen List Summary
3 7009
MAK: Not listed
NIOSH: Not listed
NTP: Not listed
ACGIH: Not listed
OSHA: Not listed
EPA CAGS Hazard Ranking : Not listed
LD50 Value : orl-rat LD50:5 gm/ kg
LD50 Value (rat) : 5000
LD50 Value (albino rabbit): Not given
LC50 Value
No data in RTECS 1992 LC50 Species : LDLO, ORAL-HUMAN.
Human Toxic Effects
* orl-hmn LDLo:6430 mg/kg PCOC** -,705,66
Human Toxicity Data
* orl-hmn LDLo:6430 mg/kg PCOC** -,705,66
1F07 skn-hmn TDLo:2414 mg/kg PCOC** -,705,66
Other Species Toxicity
* orl-rat LD50:5 gm/kg JPETAB 99,140,50
* skn-rat LD50:>6 gm/kg CMEP** -,1,56
* orl-mus LD50:1 gm/kg JAFCAU 25,859,77
* orl-rbt LD50:>6 gm/kg SPEADM 78-1,16,78
* ipr-ham LD50:500 mg/kg ARTODN 58,152,86
* orl-dck LD50:>2 gm/kg PEMNDP 9,574,91
Reproductive Toxicity
orl-rat TDLo:66 gm/kg (33D male) JPETAB 138,126,62

PATERNAL EFFECTS
Testes,epididymis,sperm duct

PATERNAL EFFECTS
Prostate,seminal vessel,Cowper's gland,accessory glands,urethra
orl-rat TDLo:2 gm/kg (6-15D preg) TXAPA9 45,435,78

EFFECTS ON FERTILITY

Post-implantation mortality

EFFECTS ON FERTILITY
Litter size(# fetuses per litter;measured before birth)

EFFECTS ON EMBRYO OR FETUS
Fetotoxicity(except death,e.g.,stunted fetus)
orl-rat TDLo:2 gm/kg (6-15D preg) TXAPA9 45,435,78

SPECIFIC DEVELOPMENTAL ABNORMALITIES
Musculoskeletal system
orl-rat TDLo:4250 mg/kg (42D pre-21D post) JAFCAU 22,969,74

MATERNAL EFFECTS
Ovaries,fallopian tubes

EFFECTS ON NEWBORN
Physical

EFFECTS ON NEWBORN
Delayed effects
orl-rat TDLo:10625 mg/kg (42D pre-21D post) JAFCAU 22,969,74

MATERNAL EFFECTS
Uterus,cervix,vagina

EFFECTS ON FERTILITY
Mating performance

EFFECTS ON FERTILITY
Female fertility index
unr-rat TDLo:7 gm/kg (70D male) AHEMA5 9,89,80

PATERNAL EFFECTS
Spermatogenisis
unr-rat TDLo:2100 mg/kg (21D pre) AHEMA5 9,89,80

MATERNAL EFFECTS
Oogenesis
unr-rat TDLo:9100 mg/kg (70D male/21D pre) AHEMA5 9,89,80

EFFECTS ON FERTILITY
Mating performance

orl-mus TDLo:1 gm/kg (20D preg) REPTED 5,139,91

MATERNAL EFFECTS
Ovaries,fallopian tubes
orl-mus TDLo:900 mg/kg (6-8D preg) REPTED 6,431,92

MATERNAL EFFECTS
Uterus,cervix,vagina
orl-mus TDLo:2 gm/kg (6-15D preg) REPTED 6,431,92

MATERNAL EFFECTS
Parturition

Toxicity Data (RTECS)
* orl-hmn LDLo:6430 mg/kg PCOC** -,705,66
skn-hmn TDLo:2414 mg/kg PCOC** -,705,66
BEHAVIORAL
Somnolence(general depressed activity)
* orl-rat LD50:5 gm/kg JPETAB 99,140,50
* skn-rat LD50:>6 gm/kg CMEP** -,1,56
* orl-mus LD50:1 gm/kg JAFCAU 25,859,77
* orl-rbt LD50:>6 gm/kg SPEADM 78-1,16,78
* ipr-ham LD50:500 mg/kg ARTODN 58,152,86

Irritation Data (RTECS)
No data

Reproductive Toxicology
orl-rat TDLo:66 gm/kg (33D male) JPETAB 138,126,62
REPRODUCTIVE EFFECTS CODES
PATERNAL EFFECTS
Testes,epididymis,sperm duct
REPRODUCTIVE EFFECTS CODES
PATERNAL EFFECTS
Prostate,seminal vessel,Cowper's gland,accessory glands,urethra
orl-rat TDLo:2 gm/kg (6-15D preg) TXAPA9 45,435,78
REPRODUCTIVE EFFECTS CODES
EFFECTS ON FERTILITY
Post-implantation mortality
REPRODUCTIVE EFFECTS CODES
EFFECTS ON FERTILITY
Litter size(# fetuses per litter;measured before birth)
REPRODUCTIVE EFFECTS CODES
EFFECTS ON EMBRYO OR FETUS
Fetotoxicity(except death,e.g.,stunted fetus)
orl-rat TDLo:2 gm/kg (6-15D preg) TXAPA9 45,435,78

REPRODUCTIVE EFFECTS CODES
SPECIFIC DEVELOPMENTAL ABNORMALITIES
Musculoskeletal system
orl-rat TDLo:4250 mg/kg (42D pre-21D post) JAFCAU 22,969,74
REPRODUCTIVE EFFECTS CODES
MATERNAL EFFECTS
Ovaries,fallopian tubes
REPRODUCTIVE EFFECTS CODES
EFFECTS ON NEWBORN
Physical
REPRODUCTIVE EFFECTS CODES
EFFECTS ON NEWBORN
Delayed effects
orl-rat TDLo:10625 mg/kg (42D pre-21D post) JAFCAU 22,969,74
REPRODUCTIVE EFFECTS CODES
MATERNAL EFFECTS
Uterus,cervix,vagina
REPRODUCTIVE EFFECTS CODES
EFFECTS ON FERTILITY
Mating performance
REPRODUCTIVE EFFECTS CODES
EFFECTS ON FERTILITY
Female fertility index
unr-rat TDLo:7 gm/kg (70D male) AHEMA5 9,89,80
REPRODUCTIVE EFFECTS CODES
PATERNAL EFFECTS
Spermatogenisis
unr-rat TDLo:2100 mg/kg (21D pre) AHEMA5 9,89,80
REPRODUCTIVE EFFECTS CODES
MATERNAL EFFECTS
Oogenesis
unr-rat TDLo:9100 mg/kg (70D male/21D pre) AHEMA5 9,89,80
REPRODUCTIVE EFFECTS CODES
EFFECTS ON FERTILITY
Mating performance
orl-mus TDLo:1 gm/kg (20D preg) REPTED 5,139,91
REPRODUCTIVE EFFECTS CODES
MATERNAL EFFECTS
Ovaries,fallopian tubes
orl-mus TDLo:900 mg/kg (6-8D preg) REPTED 6,431,92
REPRODUCTIVE EFFECTS CODES
MATERNAL EFFECTS
Uterus,cervix,vagina

orl-mus TDLo:2 gm/kg (6-15D preg) REPTED 6,431,92
REPRODUCTIVE EFFECTS CODES
MATERNAL EFFECTS
Parturition
Mutagenic Data : rat mouse hamster
Teratogenic Data : Y Ref:
Routes of Entry : INHALATION, INGESTION ** Source: HTHC
From Deutsche Forschungsgemeinshaft Reports
MAK Information
MAK workplace concentration data:
15 calculated as total dust mG/M3
Substance with systemic effects, onset of effect over 2 hours: Peak = 10xMAK for 30 minutes, once per shift of 8 hours.
Teratogenic Data Group : MAK workplace concentration data Not listed
Carcinogenic Data Group : MAK workplace concentration data Not listed
Abnormal Sensitivity : MAK data Not listed
Max Workplace Conc. : 15 calculated as total dust
Exposure Peak Limits : MAK data Substance with systemic effects, onset of effect over 2 hours: Peak = 10xMAK for 30 minutes, once per shift of 8 hours.

FIRST AID AND PERSONAL PROTECTION INFO----------

First Aid
CHEMICAL: METHOXYCHLOR
SOURCE: CHRIS Manual 1991
EYES: flush with water if irritated.
SKIN: wash well with soap and water.
INGESTION: consult physician.
SOURCE: DOT Emergency Response Guide 1990.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water. Remove and isolate contaminated clothing and shoes at the site.
Protection Suggested
ACGIH Protect Guidelines: METHOXYCHLOR **********
Butyl CPE
Nat. rubber Neoprene Nitrile Nitrile/PVC PE Polyurethane PVA PVC
SBR VITON
Med Conditions Aggrav. : Unknown
NIOSH Respirator Selection Info

ACGIH (METHOXYCHLOR)

100 mg/M3: Any chemical cartridge respirator with organic vapor cartridge(s) in combination with a dust, mist and fume filter. / Any supplied-air respirator. / Any self-contained breathing apparatus.

250 mg/M3: Any supplied-air respirator operated in a continuous flow mode. / Any powered air-purifying respirator with organic vapor cartridge(s) in combination with a dust, mist, and fume filter.

500m: Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s) in combination with a high-efficiency particulate filter. / Any supplied-air respirator with a full facepiece. / Any powered air-purifying respirator with a tight-fitting facepiece and organic vapor cartridge(s) in combination with a high-efficiency particulate filter. / Any self-contained breathing apparatus with a full facepiece. / Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister having a high-efficiency particulate filter. / Any supplied-air respirator with a tight-fitting facepiece operated in a continuous flow mode.

7500 mg/M3: Any supplied-air respirator with a half-mask and operated in a pressure-demand or other positive pressure mode.

EMERGENCY OR PLANNED ENTRY IN UNKNOWN CONCENTRATIONS OR IDLH

CONDITIONS.: Any self-contained breathing apparatus with full facepiece and operated in a pressure-demand or other positive pressure mode. / Any supplied-air respirator with a full facepiece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

ESCAPE: Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister having a high-efficiency particulate filter. / Any appropriate escape-type self-contained breathing apparatus.

SPILL, STORAGE, AND INITIAL INCIDENT RESPONSE INFORMATION----------

DOT Shipping Name : ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S. (METHOXYCHLOR)

DOT ID Number : UN3077

DOT Hazard Class : 9 CLASS 9

DOT Guide Information

DOT SHIPPING NAME: ENVIRONMENTALLY HAZARDOUS SUBSTANCES, SOLID, N.O.S.
(METHOXYCHLOR)
DOT ID NUMBER: UN3077

ERG93 GUIDE 31
POTENTIAL HAZARDS
*FIRE OR EXPLOSION
Some of these materials may burn, but none of them ignites readily.
Material may be transported hot.
*HEALTH HAZARDS
Contact may cause burns to skin and eyes.
Inhalation of asbestos dust may have a damaging effect on the lungs.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection. CALL Emergency Response Telephone Number on Shipping Paper
first. If Shipping Paper not available or no answer, CALL CHEMTREC AT
1-800-424-9300. If water pollution occurs, notify the appropriate authorities.
*FIRE
Small Fires: Dry chemical, CO2, water spray or regular foam.
Large Fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
*Do not scatter spilled material with high-pressure water streams.
Dike fire control water for later disposal.
*SPILL OR LEAK
Stop leak if you can do it without risk.
Avoid inhalation of asbestos dust.
Small Dry Spills: With clean shovel place material into clean, dry container
and cover loosely; move containers from spill area.
Small Spills: Take up with sand or other noncombustible absorbent material
and place into containers for later disposal.
Large Spills: Dike far ahead of liquid spill for later disposal.
Cover powder spill with plastic sheet or tarp to minimize spreading.
*FIRST AID

In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water. Remove and isolate contaminated clothing and shoes at the site.
Initial Isolation Distance: Not given
Extinguishing Media : Water, foam, dry chemical, carbon dioxide.
CHRIS91

DISCLAIMER: The data shown above on this chemical represents a best effort on the part of the compilers of the CHEMTOX database to obtain useful, accurate, and factual data. The use of these data shall be in accordance with the guidelines and limitations of the user's CHEMTOX license agreement.
The COMPILERS of the CHEMTOX database shall not be held liable for inaccuracies or omissions within this database, or in any of its printed or displayed output forms

5/4/1
FN- DIALOG(R)File 337:CHEMTOX(R)|
CZ- (c) 1995 Resource Consultants, Inc. All rts. reserv.|
AN- 00005702
NM- CHEMICAL IDENTITY|
CN- <Chemical Name> HEPTACHLOR EPOXIDE|
SY- <Synonym> ENT 25,584; EPOXYHEPTACHLOR; HCE; HEPTACHLOR EPOXIDE;
1,4,5,6,7,8,8-HEPTACHLORO-2,3-EPOXY-2,3,3a,4,7,7a-HEXAHYDRO-
4,7-METHANOINDENE; 1,4,5,6,7,8,8-HEPTACHLORO-2,3-EPOXY-3a,4,7,7a-TETR

AHYDRO-4,7-METHANOINDAN; 2,3,4,5,6,7,7-HEPTACHLORO-1a,1b,5,5a,6,6a-HE
XAHYDRO-2,5-METHANO-2H-INDENO(1,2-b)OXIRENE; HIPTACHLOR EPOXIDE;
2,5-METHANO-2H-OXIRENO(a)INDENE,
2,3,4,5,6,7,7-HEPTACHLORO-1a,1b,5,5a,6,6a-HEXAHYDRO-; VELSICOL 53-CS-17
|
RN- <CAS Registry Number> 1024-57-3|
RR- <RTECS (NIOSH) ID Number> PB9450000|
MF- <Molecular Formula> C10H5Cl7O|
MW- <Molecular Weight> 399.30|
WL- <Wisswesser Line Notation> T D3 C555 A EO JUTJ AG AG BG GG IG JG KG|
UP- <Last Record Update by CHEMTOX> 03/09/95|
PP- PHYSICAL PROPERTY INFORMATION|
AC- <Auto Ignition Temp in C> -|
AK- <Auto Ignition Temp in K> ~|
AF- <Auto Ignition Temp in F> -|
FP- <Flash Point in C> ~|
FK- <Flash Point in K> ~|
FF- <Flash Point in F> ~|
VP- <Vapor Pressure in psi> No data|
VD- <Vapor Specific Gravity> No data|
EV- <Evaporation Rate> Not given|
UE- <Upper Explosive Limit> Not applicable|
LE- <Lower Explosive Limit> Not applicable|
AB- <Absorbance Units> No data|
WA- <Water Reactivity> No data on water reactivity|
RC- <Common Material Reactions> No data|
ST- <Stability During Transport> No Data|
PL- <Polymerization Possibility> No data|
PQ- <Practical Quantitation Limit> 1; 10|
TF- <Toxic Fire Gases> HYRDOGEN FCLHLORIDEDR|
OD- <Odor Description> No desc given|
OH- <Odor Detected by 100% population> No data|
OL- <Odor Detection Lower Limit> No data|
US- <Uses> Condensed Chemical Dictionary, 10th ed.|
RG- REGULATORY INFORMATION|
DO- DOT - Department of Transportation|
DQ- <DOT Shipping Name> ORGANOCHLORINE PESTICIDES SOLID TOXIC, N.O.S.|
DO- <DOT Identification Number> UN2761|

DC- <DOT Hazard Class> 6.1 POISON|
DG- <DOT Guide Number> 55|
DL- <DOT Label(s) Required> POISON|
CW- EPA Water - Environmental Protection Agency|
CW- <Clean Water Act (CWA) Listed> Sec 307|
C5- <CWA Priority Pollutant> Yes|
CX- <CWA Hazardous Substance Listed> No|
ML- <Max Water Contaminant Level> 0.0002 mg/L (07/30/92)|
MY- <EPA Water Max Contaminant Level> 0 mg/L (07/30/92)|
MR- <Marine Pollutant> Not listed|
CA- EPA AIR - Environmental Protection Agency|
CA- <Clean Air Act Reference> Not listed|
SZ- EPA SUPERFUND - Environmental Protection Agency|
SZ- <SARA 312 Categories> Acute toxicity: Highly toxic. LD50 is 50 mg/kg or
less (oral rat).
Chronic toxicity: carcinogen|
RQ- <CERCLA Reportable Qty Symbol> X CERCLA|
RS- <CERCLA Reportable Quantity (lbs)> 1 pound (0.454 kg) CERCLA|
TP- <TPQ (Threshold Planning Quantity)> Not listed|
MI- <US Postal Service Mailability Info> Not given|
NF- NFPA - National Fire Protection Association Code Information|
NF- <Health Hazard Code (BLUE)> Unspecified|
NR- <NFPA Flammability Code (RED)> Unspecified|
NY- <NFPA Reactivity Code (YELLOW)> Unspecified|
NS- <NFPA Special Code> Unspecified|
OS- OSHA - Occupational Safety & Health Administration|
SI- <OSHA Short Term Exposure Limits> Not in Table Z-1-A|
QC- <OSHA Exposure Limit Comments> SKIN|
TW- <OSHA 8 Hr Time Limit> Not in Table Z-1-A|
HS- <OSHA HS System ID Number> Not given|
CE- <OSHA Ceiling/Air Contaminants> Not in Table Z-1-A|
EP- EPA - Environmental Protection Agency|
GW- <EPA Waste Analytical Method> 8080 8270|
TC- <EPA Toxic Characteristics ID Num> None|
FR- <EPA FIFRA Pesticide Registration> Not listed|
TS- <TSCA Status> EPA TSCA Test Submission (TSCATS) Database - September
1989
EPA TSCA Test Submission (TSCATS) Database - April 1990
TSCA Rulemaking|
LL- State Regulatory Information|
LL- <List of Lists/California> (B) EPA List of Priority Pollutants.

(C) AB 1803 Well Monitoring Chemicals.
(F) M.C.L. (Maximum Contaminant Levels) List.
(G) AB 2588 Air Toxics "Hot Spots" Chemicals.
(H) D.H.S. Drinking Water Action List.
(K) Prop. 65 Chemicals List.|
LM- List of Lists/Massachusettes> HEPTACarcinogenHLOR EPOXIDE
OSHA
FEPA|
LN- <List of Lists/New Jersey> List number 2997|
NN- <Substance Number/New Jersey> 2997|
LP- <Haz Substance List/Pennsylvania> Environmental Hazard|
HD- <Hazard Designation/Washington> NA|
WH- <Canada Ingred Disclosure Listed> N|
TQ- OTHER|
TQ- <Threshhold Quantity> Not listed|
TR- <Toxic Characteristic Reg Level> Not given|
LO- Summary of Regulatory Lists That This Substance Appears On|

LO- <List of Lists> ACGIH TLV list "Threshold Limit Values for 1992-1993"
ATSDR Toxicology Profile available (NTIS** PB/89/194492/AS)
California Assembly Bill 1803 Well Monitoring Chemicals.
California Assembly Bill 2588 Air Toxics "Hot Spots" Chemicals.
California Department of Health Services Drinking Water Action List.
Clean Water Act Section 307 Priority Pollutants
EPA TSCA Test Submission (TSCATS) Database - April 1990
EPA TSCA Test Submission (TSCATS) Database - September 1989
HEPTACHLOR EPOXIDE [1024-57-3]
Massachusetts Substance List.
New Jersey Right To Know Substance List. (December 1987)
Pennsylvania Hazardous Substance List
RCRA Hazardous Constituents for Ground Water Monitoring. Ap'dx IX to 40
CFR 264
SARA Section 110 Priority List of CERCLA Hazardous Substances
Superfund/CERCLA RQ list. Table 302.4 in 54 FR 50968 (December 11,
1989)|
TO- TOXICITY INFORMATION|
SX- <Short Term Toxicity> Unknown|
LT- <Long Term Toxicity> Unknown|
RL- NIOSH REL|
RL- <NIOSH Exposure Limits> Not given|

TL- <Threshold Limit Value ACGIH> TLV = 0.05mg/M3 SKIN A3|
SE- <ACGIH Short Term Exposure Limit> Not listed|
PE- OSHA PEL|
PE- <OSHA Air Contaminants Limits> Not in Table Z-1-A|
CR- <Carcinogen Data Flag> N|
NC- <RTECS Carcinogen Determination> ANIMAL POSITIVE IARC** 20,129,79
ANIMAL INDEFINITE IARC** 5,173,74 HUMAN INDEFINITE IARC** 20,129,79|
CI- Carcinogen Lists|
CI- <IARC Carcinogenicity Code> 2B 8325|
CM- <MAK Carcinogenicity Code> No|
CJ- <NIOSH Carcinogenicity Code> Y|
CQ- <NTP Carcinogenicity Code> No|
CH- <ACGIH Carcinogenicity Code> No|
OS- <OSHA Carcinogenicity Code> No|
CT- <Carcinogen Summary> 2B 8325
MAK: Not listed
NIOSH: Not listed
NTP: Not listed
A3
OSHA: Not listed|
CG- <EPA CAG (Carcinogen) Hazard> HIGH|
LD- <LD50 (Lethal Dose)> orl-rat LD50:3434 ug/ kg|
LZ- <LD50 Species (RTECS)> RAT|
LR- <LD50 for Rats (RTECS)> 3.434|
LS- <LD50 for Albino Rabbits Skin> Not given|
LC- <LC50 (Lethal Concentration)> No data in RTECS 1992|
OT- <Other Species Toxicity Data> * orl-rat LD50:3434 ug/kg PSSCBG 15,31,84
|
RP- <RTECS Reproductive Toxicity> Not given|
IR- <Irritation Data (RTECS)> No data|
MU- <RTECS Mutagenic Data> Not listed in RTECS 1992|
TT- <Teratogenic Data> N Ref:|
RE- <Routes of Entry> Unknown|
MX- From Deutsche Forschungsgemeinshaft Reports: MAK Information|
MX- <Max Tolerance Values> MAK workplace concentration data:
Not listed|
MG- <Max Workplace/Fetal Damage> MAK workplace concentration data: Not
listed|

MZ- <Carcinogenicity Grouping> MAK workplace concentration data: Not listed
|
MH- <Higher Than Normal Sensitivities> MAK data: Not listed|
MO- <Exposure Peak Limitations> MAK data: Not listed|
FA- FIRST AID AND PERSONAL PROTECTION INFO|
FA- <First Aid Information> CHEMICAL: HEPTACHLOR EPOXIDE
SOURCE: DOT Emergency Response Guide 1990.
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen. In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes. Speed in removing material from skin is of extreme importance. Removal of solidified molten material from skin requires medical assistance. Remove and isolate contaminated clothing and shoes at the site. Keep victim quiet and maintain normal body temperature. Effects may be delayed; keep victim under observation.|
CC- Protection Suggested|
CC- <Protective Clothing Guidelines> HEPTACHLOR EPOXIDE; ********** ;
Butyl ; CPE ; Nat. rubber ; Neoprene ; Nitrile ; Nitrile/PVC ; PE ; Polyurethane ; PVA ; PVC ; SBR ; VITON|
AX- <ACGIH Comments on Exposure> SKIN|
MA- <Medical Conditions Aggravated> Unknown|
HZ- SPILL, STORAGE, AND INITIAL INCIDENT RESPONSE|
DQ- <DOT Shipping Name> ORGANOCHLORINE PESTICIDES SOLID TOXIC, N.O.S.|
DO- <DOT Identification Number> UN2761|
DC- <DOT Hazard Class> 6.1 POISON|
DI- <DOT Guide Information> DOT SHIPPING NAME:
ORGANOCHLORINE PESTICIDES
SOLID TOXIC, N.O.S.
DOT ID NUMBER: UN2761

ERG93 GUIDE 55
POTENTIAL HAZARDS
*HEALTH HAZARDS
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may give off poisonous gases and
cause water pollution.
Fire may produce irritating or poisonous gases.

*FIRE OR EXPLOSION
Some of these materials may burn, but none of them ignites readily.
Container may explode violently in heat of fire.
Material may be transported in a molten form.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry. Stay upwind, out of low areas, and ventilate closed spaces before entering. Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
*Structural firefighters' protective clothing is not effective for these materials. See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action. Remove and isolate contaminated clothing at the site. CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, CALL CHEMTREC AT 1-800-424-9300.
*FIRE
Small Fires: Dry chemical, water spray or regular foam.
Large Fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Fight fire from maximum distance. Stay away from ends of tanks.
Dike fire control water for later disposal; do not scatter the material.
*SPILL OR LEAK
Do not touch or walk through spilled material; stop leak if you can do it without risk. Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire. Use water spray to reduce vapors.
Small Spills: Take up with sand or other noncombustible absorbent material
and place into containers for later disposal. Small Dry Spills: With clean
shovel place material into clean, dry container and cover loosely; move

containers from spill area.
Large Spills: Dike far ahead of liquid spill for later disposal.
*FIRST AID
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen. In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes. Speed in removing

material from skin is of extreme importance. Removal of solidified molten material from skin requires medical assistance. Remove and isolate contaminated clothing and shoes at the site. Keep victim quiet and maintain normal body temperature. Effects may be delayed; keep victim under observation.|
IS- <Initial Isolation Distance> Not given|
EX- <Extinguishing Media> Not given|

DISCLAIMER: The data shown above on this chemical represents a best effort on the part of the compilers of the CHEMTOX database to obtain useful, accurate, and factual data. The use of these data shall be in accordance with the guidelines and limitations of the user's CHEMTOX license agreement.
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6/5/1
DIALOG(R)File 337:CHEMTOX(R)
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00006504
IDENTIFIER INFORMATION----------
Chemical Name : 4,7-METHANOINDAN,
1-alpha,2-alpha,4-beta,5,6,7-beta,8,8-OCTACHLORO-3a-alpha,4,7,7a-alp

ha-TETRAHYDRO-
Synonym(s) : alpha-CHLORDAN; cis-CHLORDAN; alpha-CHLORDANE
; alpha(cis)-CHLORDANE; cis -CHLORDANE
CAS Registry Number : 5103-71-9
RTECS Number : PB9705000
Molecular Formula : C10H6Cl8
Molecular Weight : 409.76
Chemical Class : T
Wisswesser Line Notation : L C555 A IUTJ AG AG BG DG EG HG IG JG
Record Last Updated : 11/06/93

PHYSICAL PROPERTY INFORMATION----------

Auto Ignition in C : -
Auto Ignition in F : -
Auto Ignition in K : ~
Flash Point in C : ~
Flash Point in F : ~
Flash Point in K : ~
Vapor Pressure (psi) : No data
Vapor Specific Gravity : No data
Evaporation Rate : Not given
Upper Explosive Limit : ~
Lower Explosive Limit : ~
Absorbance Units : No data
Reactivity w/ Water : No data on water reactivity
Reactivity w/ Common Mtl : No data
Stability During Transport : No Data
Polymerization Possibile : No data
Toxic Fire Gases : None reported other than possible unburned vapors
Odor Description : No desc given
Odor (100% Pop. Detection) : No data
Odor Detection Lower Limit : No data
Uses : Not listed

REGULATORY INFORMATION----------

DOT - Department of Transportation
DOT Hazard Class : Not given
DOT Label(s) Required : Not given

EPA Water - Environmental Protection Agency
Clean Water Act (CWA) : Not covered
CWA Priority Pollutant : No
CWA Hazardous Sub Listed: No
MCL (Max Contam Level) : Not specified
MCLG (Max Contam Goal) : Not specified
Marine Pollutant List : Not listed
EPA AIR - Environmental Protection Agency
Clean Air Act : Not listed
EPA SUPERFUND - Environmental Protection Agency
SARA 312 Categories
Chronic toxicity: carcinogen
CERCLA RQ Symbol : Not listed
CERCLA RQ (Rep. Qty) : Not listed
TPQ (Threshold Pl. Qty.): Not listed
USPS - US Postal Service
Not given
NFPA - National Fire Protection Association Code Information
Health Hazard (BLUE) : Unspecified
Flammability (RED) : Unspecified
Reactivity (YELLOW) : Unspecified
Special : Unspecified
OSHA - Occupational Safety & Health Administration
STEL : Not in Table Z-1-A
8 Hour Air Contam Limit : Not in Table Z-1-A
HS System ID : Not given
Air Contam Ceiling Limit: Not in Table Z-1-A
EPA - Environmental Protection Agency
Toxic Characteristics ID: None
Pesticide Rereg Ingred : Not listed
TSCA Status
Not listed
State Regulatory Information
CA List of Lists
Not listed
CA Water List Cat & Date: Not listed
NJ List of Lists
Not listed
WA Hazard Designation : NA
Canadian Ingredients Disclosure List
Listed ? : N
OTHER
Threshhold Quantity (TQ): Not listed

Toxic Character Reg Lvl : Not given

Summary of Regulatory Lists That This Substance Appears On

4,7-METHANOINDAN,
1-alpha,2-alpha,4-beta,5,6,7-beta,8,8-OCTACHLORO-3a-alpha,4,7,7a-alp
ha-TETRAHYDRO- [5103-71-9]

TOXICITY INFORMATION----------

Short Term Toxicity
Unknown
Long Term Toxicity
Unknown
NIOSH REL
Not given
ACGIH Threshold Limit Value : Not listed
ACGIH Short Term Exposure Limit : Not listed
OSHA PEL
Not in Table Z-1-A
Carcinogen : N
Carcinogen Lists
IARC : 2B 8325
MAK : No
NTP : No
ACGIH : No
OSHA : No
Carcinogen List Summary
2B 8325
MAK: Not listed
NIOSH: Not listed
NTP: Not listed
ACGIH: Not listed
OSHA: Not listed
EPA CAGS Hazard Ranking : Not listed
LD50 Value : orl-rat LD50:500 mg/ kg
LD50 Value (rat) : 500
LD50 Value (albino rabbit): Not given
LC50 Value
No data in RTECS 1992
Other Species Toxicity
* orl-rat LD50:500 mg/kg NTIS** PB85-143766

* orl-mus LD50:125 mg/kg JAFCAU 21,1113,73
* ipr-mus LDLo:290 mg/kg TXAPA9 23,288,72

Reproductive Toxicity

ipr-mus TDLo:50 mg/kg (1D preg) BECTA6 17,559,77

EFFECTS ON FERTILITY

Pre-implantation mortility

scu-mus TDLo:9 mg/kg (3D pre) JTEHD6 3,713,77

MATERNAL EFFECTS

Uterus,cervix,vagina

Toxicity Data (RTECS)

* orl-rat LD50:500 mg/kg NTIS** PB85-143766
* orl-mus LD50:125 mg/kg JAFCAU 21,1113,73

Irritation Data (RTECS)

No data

Reproductive Toxicology

ipr-mus TDLo:50 mg/kg (1D preg) BECTA6 17,559,77

REPRODUCTIVE EFFECTS CODES

EFFECTS ON FERTILITY

Pre-implantation mortility

scu-mus TDLo:9 mg/kg (3D pre) JTEHD6 3,713,77

REPRODUCTIVE EFFECTS CODES

MATERNAL EFFECTS

Uterus,cervix,vagina

Mutagenic Data : Not listed in RTECS 1992

Routes of Entry : Unknown

From Deutsche Forschungsgemeinshaft Reports

MAK Information

MAK workplace concentration data:

Not listed

Teratogenic Data Group : MAK workplace concentration data Not listed

Carcinogenic Data Group : MAK workplace concentration data Not listed

Abnormal Sensitivity : MAK data Not listed

Exposure Peak Limits : MAK data Not listed

FIRST AID AND PERSONAL PROTECTION INFO----------

Protection Suggested

ACGIH Protect Guidelines: 4,7-METHANOINDAN,

1-alpha,2-alpha,4-beta,5,6,7-beta,8,8-OCTACHLORO-3a-alpha,4,7,7a-alp
ha-TETRAHYDRO- ********** Butyl CPE Nat. rubber Neoprene
Nitrile Nitrile/PVC PE Polyurethane PVA PVC SBR VITON
Med Conditions Aggrav. : Unknown

SPILL, STORAGE, AND INITIAL INCIDENT RESPONSE INFORMATION----------
DOT Hazard Class : Not given
DOT Guide Information
DOT SHIPPING NAME:
DOT ID NUMBER:
No guide information for this compound.
Initial Isolation Distance: Not given
Extinguishing Media : Not given

DISCLAIMER: The data shown above on this chemical represents a best effort on the part of the compilers of the CHEMTOX database to obtain useful, accurate, and factual data. The use of these data shall be in accordance with the guidelines and limitations of the user's CHEMTOX license agreement.
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?quit
16aug95 15:22:05 User227748 Session D158.2
$9.96 0.166 Hrs File337
$10.00 1 Type(s) in Format 4
$40.00 4 Type(s) in Format 5
$50.00 5 Types
$4.00 View Fee
$63.96 Estimated cost File337
$1.89 TYMNET
$65.85 Estimated cost this search
$65.94 Estimated total session cost 0.174 Hrs.
Logoff: level 38.06.09 D 15:22:06

TYMNET: call cleared by request

please log in: +++

OK

C

SITE MAPS

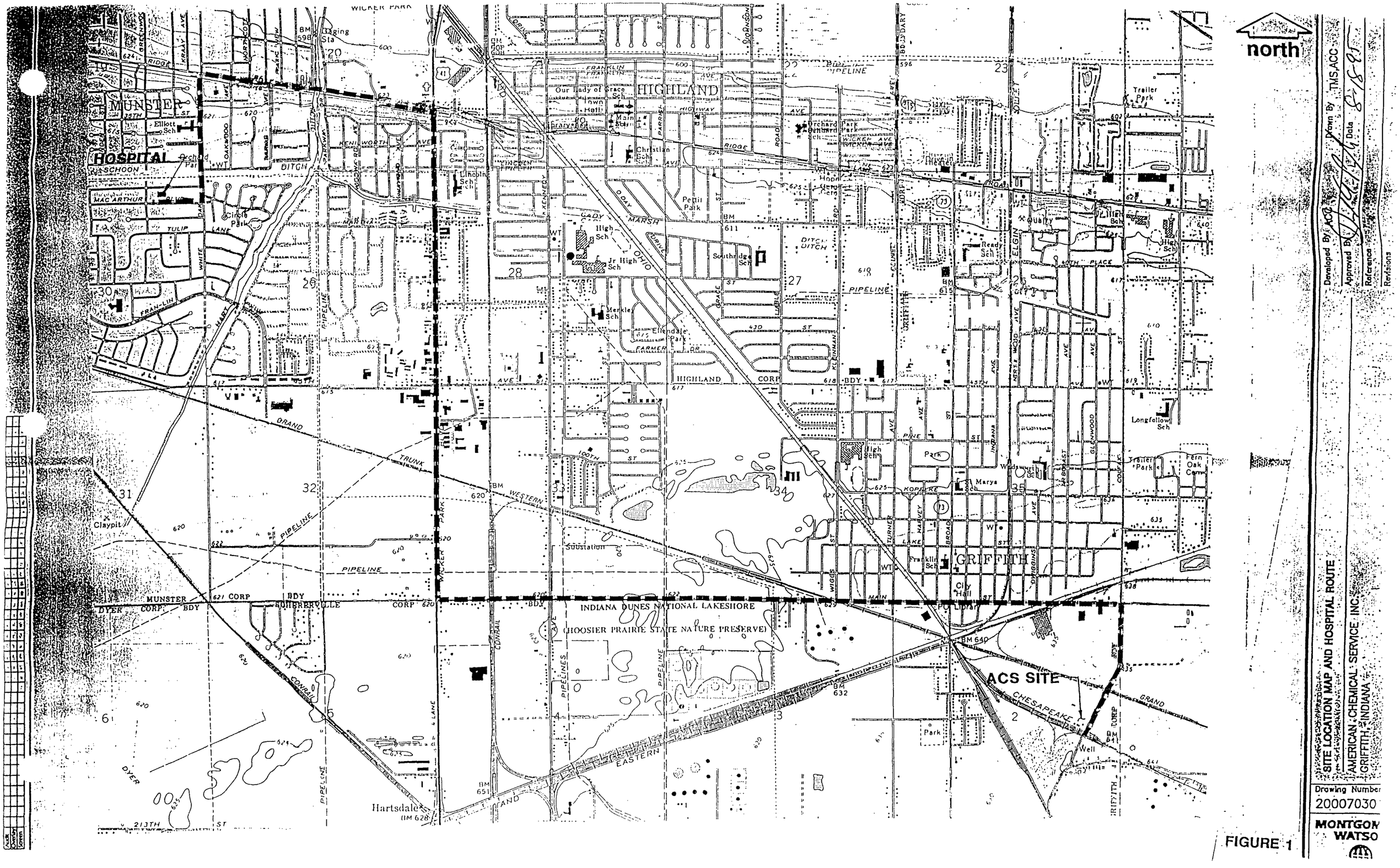
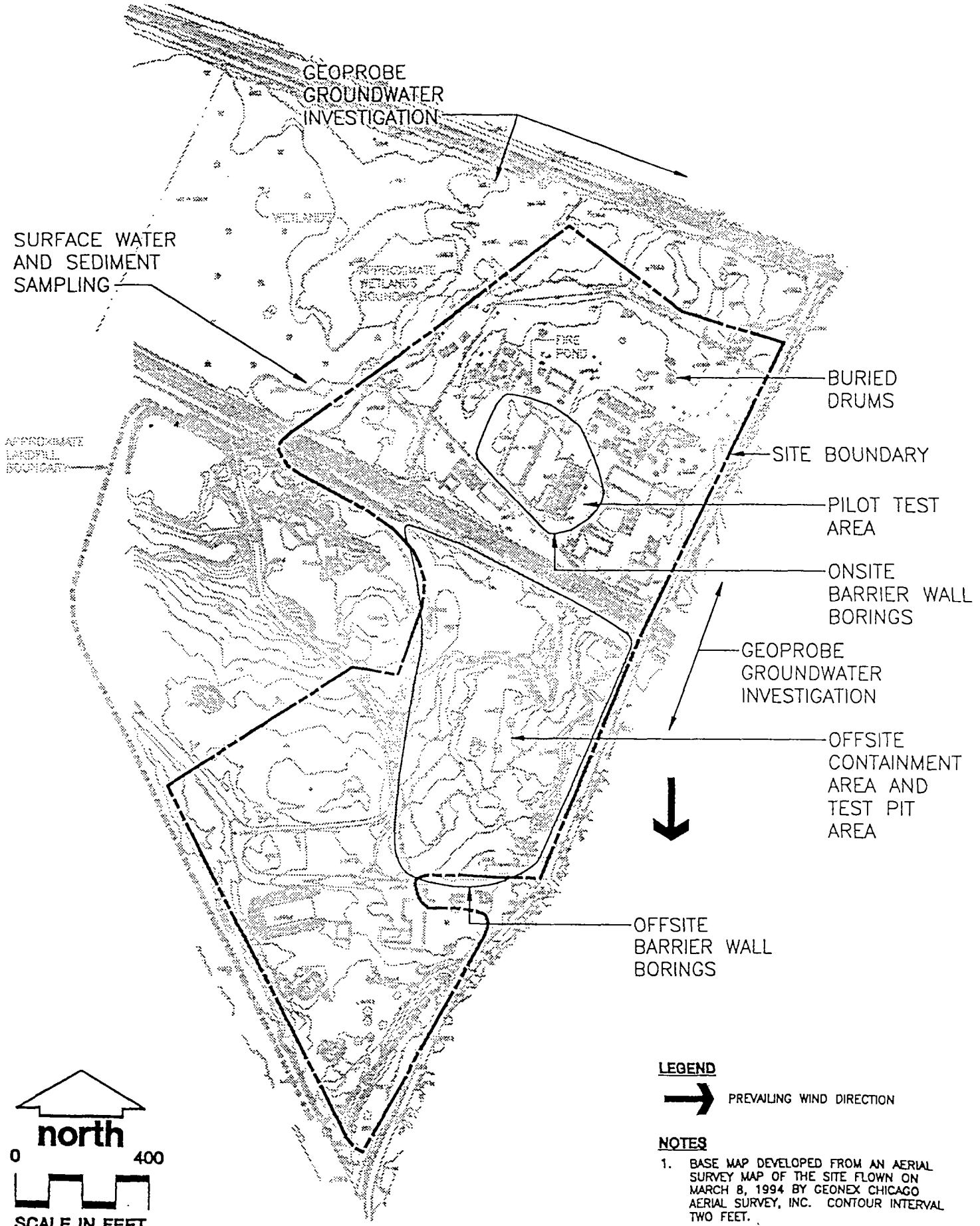

north
HOSPITAL
MUNSTER
HIGHLAND
GRIFFITH
ACS SITE
INDIANA DUNES NATIONAL LAKESHORE
(HOOSIER PRAIRIE STATE NATURE PRESERVE)
Hartsdale
Claypit
Substation
Trailer Park
Longfellow Sch
Fern Oak Cem
Pettit Park
Ellendale Park
Southridge Sch
Merkle Sch
Jr High Sch
High Sch
Christian Sch
Lincoln Sch
Elliott Sch
Orchard Park
Circle Park
Ready Sch
Quarry
City Hall
Franklin Sch
Marys Sch
Wadsworth Sch
Park
Well
Developed By ACC
Approved By
Reference
Revisions
Drawn By TMS,ACC
Date 8-18-95
SITE LOCATION MAP AND HOSPITAL ROUTE
AMERICAN CHEMICAL SERVICE INC.
GRIFFITH, INDIANA
Drawing Number
20007030
MONTGOM
WATSO

FIGURE 1



NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY MAP OF THE SITE FLOWN ON MARCH 8, 1994 BY GEONEX CHICAGO AERIAL SURVEY, INC. CONTOUR INTERVAL TWO FEET.

FIGURE 2

Developed By DAP
Approved By
Reference
Revisions

Drawn By LCL
Date 8-18-95

SITE INVESTIGATION AREAS

SITE HEALTH AND SAFETY PLAN
AMERICAN CHEMICAL SERVICE, INC.
NPL SITE
GRIFFITH, INDIANA

Drawing Number 4077.0030 A57

MONTGOMERY WATSON

QUALITY CONTROL | Graphic Standard | Lead Professional | Technical Review | Project Manager | Management Rv | Other

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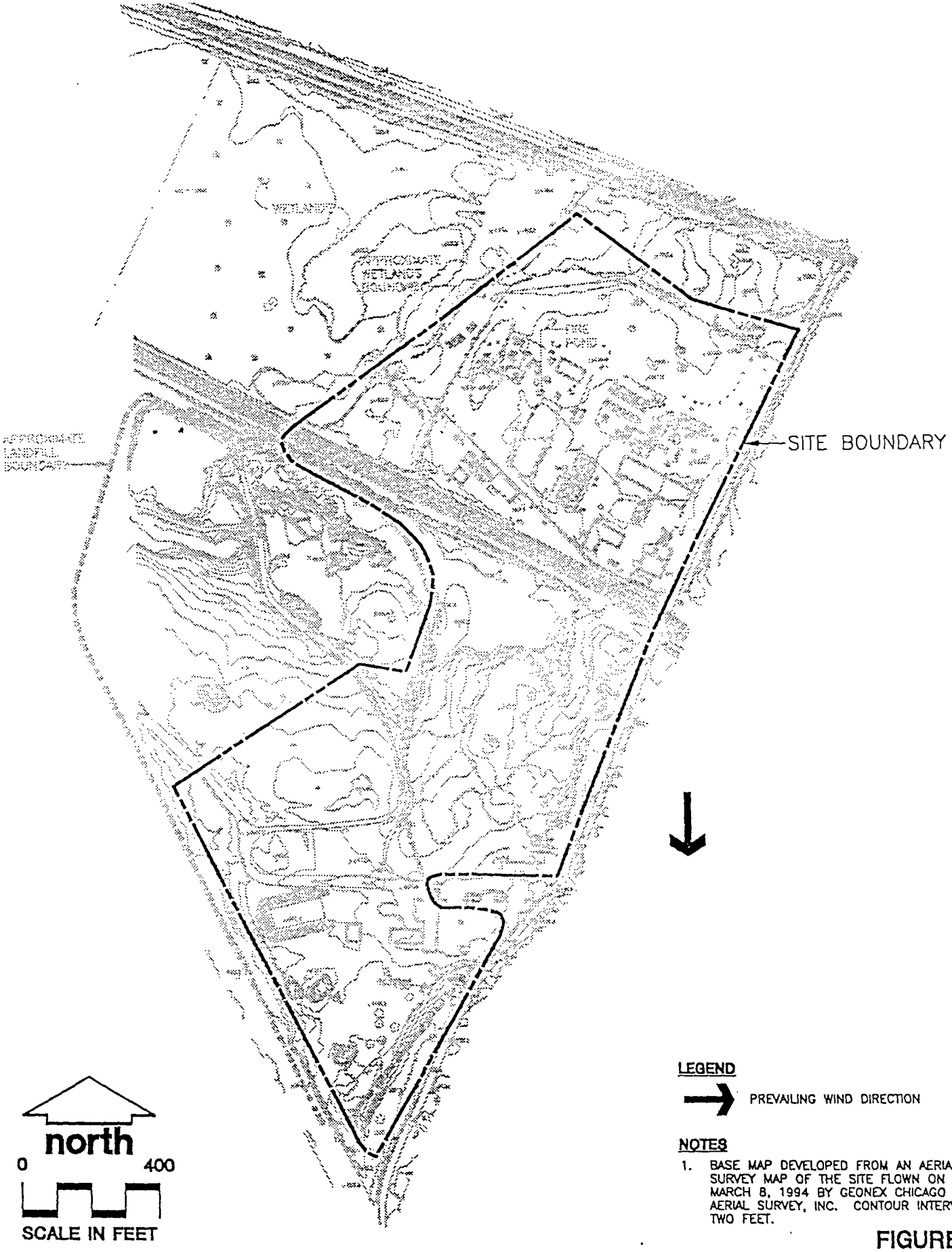

LEGEND

→ PREVAILING WIND DIRECTION

NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY MAP OF THE SITE FLOWN ON MARCH 8, 1994 BY GEONEX CHICAGO AERIAL SURVEY, INC. CONTOUR INTERVAL TWO FEET.

FIGURE 3-1

Developed By DAP	Drawn By LCL	**SITE BOUNDARY**	Drawing Number 4077.0030 **A58**
Approved By [signature]	Date 8-18-95	SITE HEALTH AND SAFETY PLAN AMERICAN CHEMICAL SERVICE, INC. NPL SITE GRIFFITH, INDIANA	**MONTGOMERY WATSON**
Reference			
Revisions			

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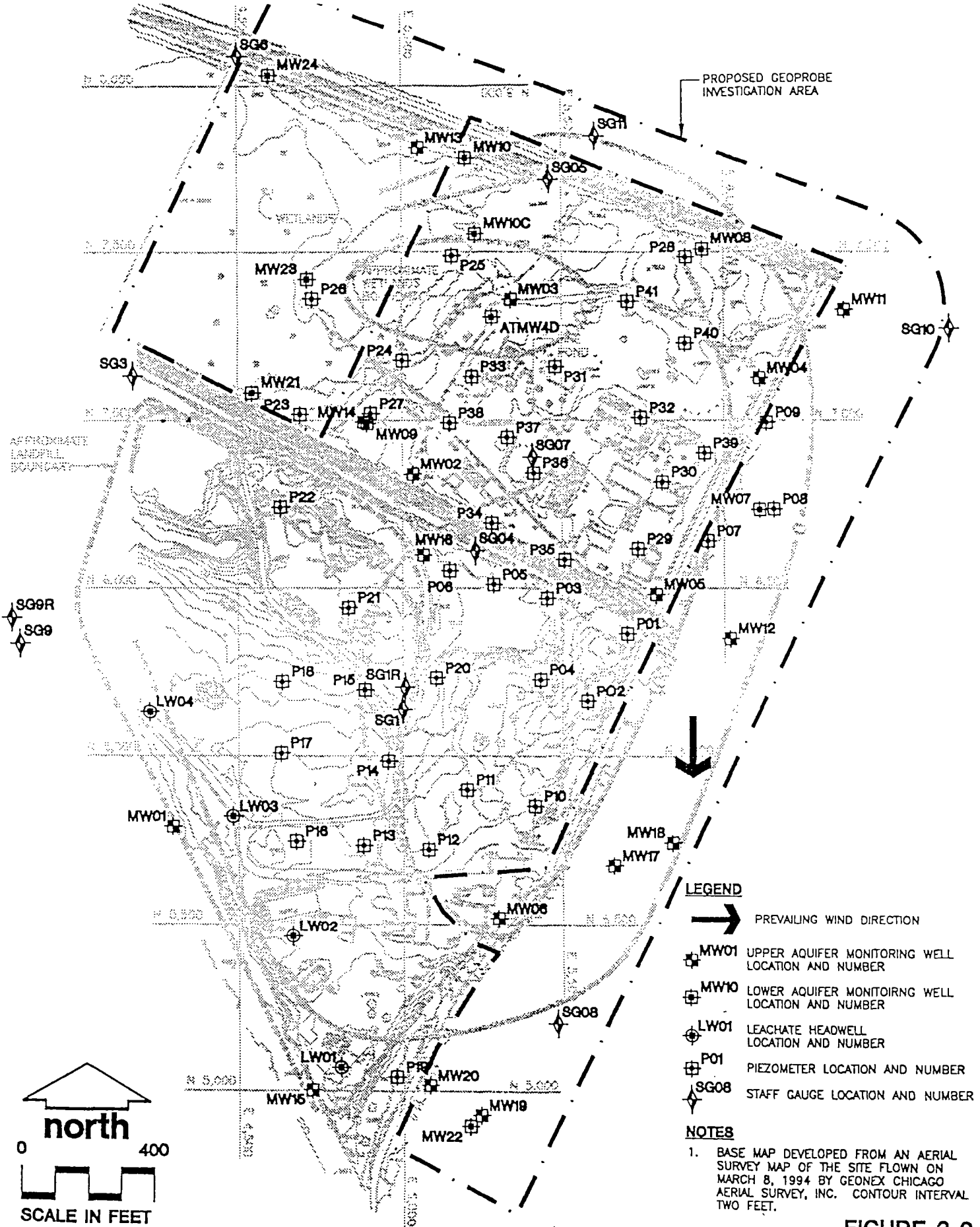

FIGURE 3-2

Management Review | Other
Technical Review | Project Manager
Graphic Standards | Lead Professionc
QUALITY CONTROL

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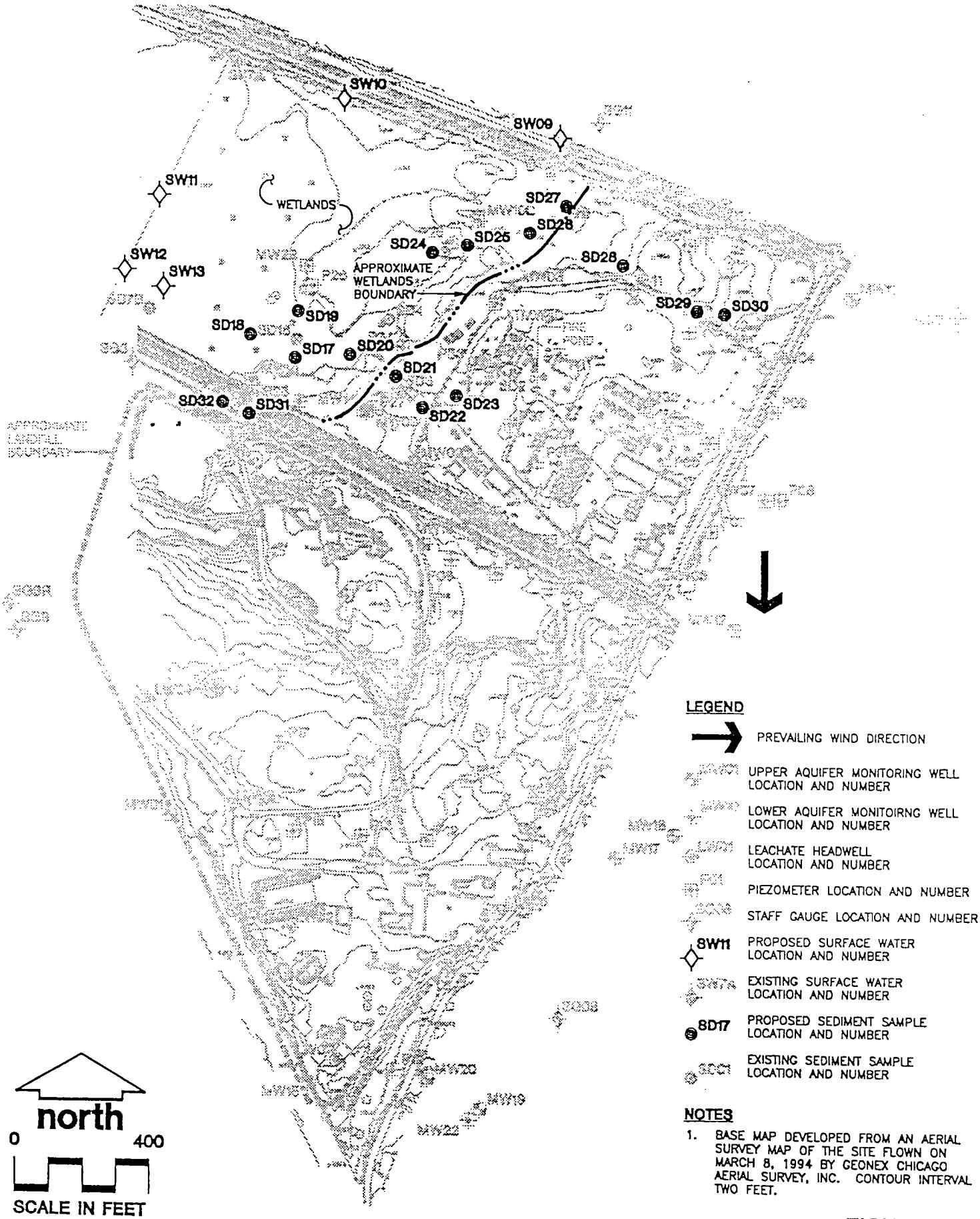
Developed By PMS,DAP,MJH	Drawn By TMS,LCL,TPB	PROPOSED TRACER GROUNDWATER INVESTIGATION AREA	Drawing Number 4077.0030 A59
Approved By [signature]	Date 8-8-95	SITE HEALTH AND SAFETY PLAN AMERICAN CHEMICAL SERVICE, INC. NPL SITE GRIFFITH, INDIANA	MONTGOMERY WATSON
Reference			
Revisions			



LEGEND

- PREVAILING WIND DIRECTION
- UPPER AQUIFER MONITORING WELL LOCATION AND NUMBER
- LOWER AQUIFER MONITOIRNG WELL LOCATION AND NUMBER
- LEACHATE HEADWELL LOCATION AND NUMBER
- PIEZOMETER LOCATION AND NUMBER
- STAFF GAUGE LOCATION AND NUMBER
- SW11 PROPOSED SURFACE WATER LOCATION AND NUMBER
- EXISTING SURFACE WATER LOCATION AND NUMBER
- SD17 PROPOSED SEDIMENT SAMPLE LOCATION AND NUMBER
- EXISTING SEDIMENT SAMPLE LOCATION AND NUMBER

NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY MAP OF THE SITE FLOWN ON MARCH 8, 1994 BY GEONEX CHICAGO AERIAL SURVEY, INC. CONTOUR INTERVAL TWO FEET.

Management
Other
Technical Review
Project Manager
Graphic Stand
Lead Professi
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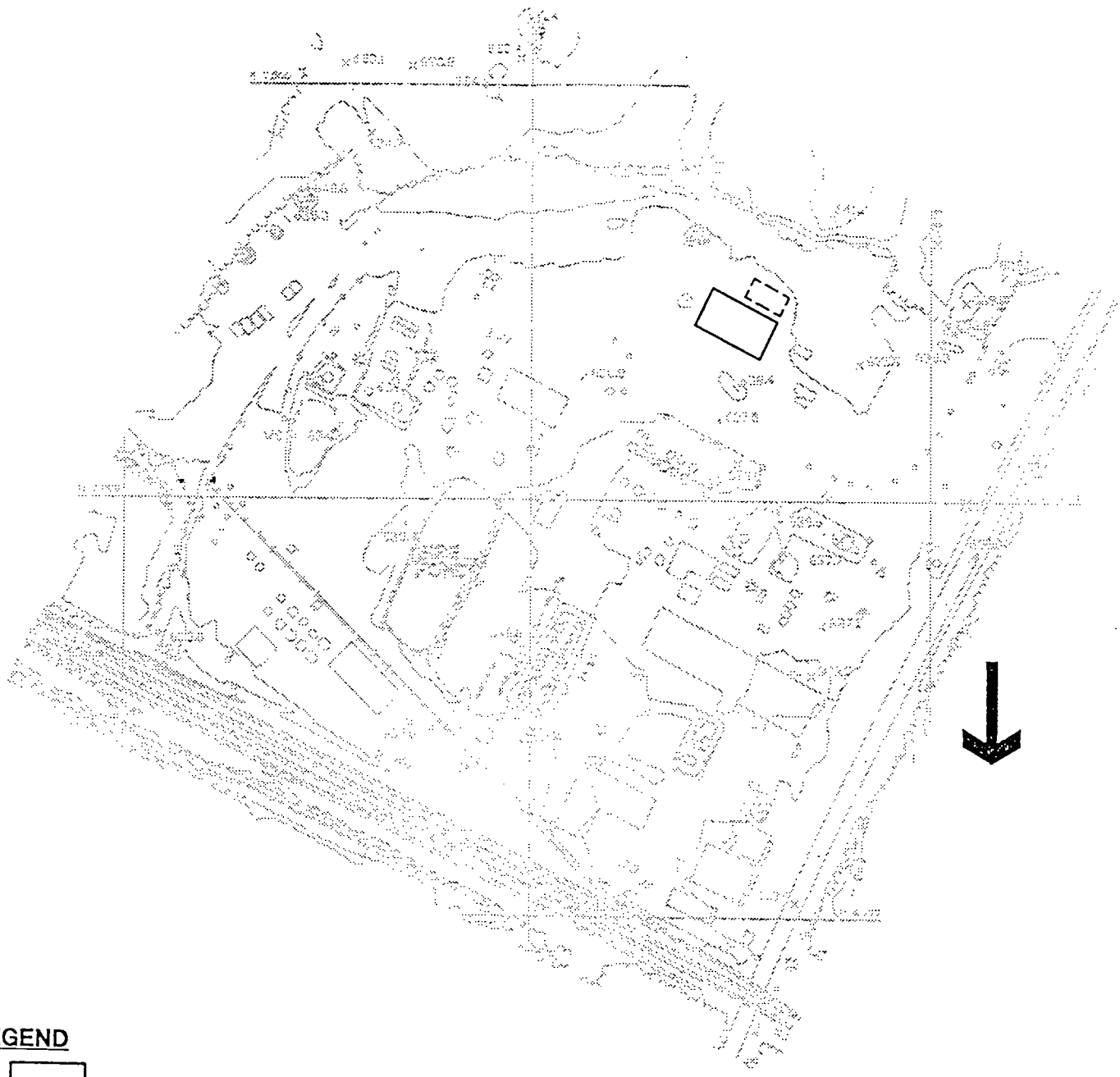
FIGURE 3-3

Developed By PMS,DAP,MJH	Drawn By TMS,LCL,TPB	WETLANDS SAMPLE LOCATION MAP	Drawing Number 4077.0030 A62
Approved By [signature]	Date 8-18-95	SITE HEALTH AND SAFETY PLAN AMERICAN CHEMICAL SERVICE, INC. NPL SITE GRIFFITH, INDIANA	MONTGOMERY WATSON
Reference			
Revisions			

QUALITY CONTROL | Graphic Standards: Lead Professional | Technical Review: Project Manager | Management Review: Other



LEGEND

- DECONTAMINATION PAD
- SITE TRAILER AND SUPPORT ZONE
- RAILROAD TRACK
- TOPOGRAPHIC CONTOUR
- PREVAILING WIND DIRECTION

NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY MAP OF THE SITE FLOWN ON MARCH 8, 1994 BY GEONEX CHICAGO AERIAL SURVEY, INC.
2. VERTICAL DATUM IS U.S.G.S. DATUM. CONTOUR INTERVAL IS 2 FEET.

north

0 200 400

SCALE IN FEET

FIGURE 3-4

Developed By PMS/DAP	Drawn By TPB,LCL	DECONTAMINATION PAD/SUPPORT ZONE LOCATION MAP (ON SITE)	Drawing Number 4077.0030 A60
Approved By [signature]	Date 8-18-95	SITE HEALTH AND SAFETY PLAN AMERICAN CHEMICAL SERVICE, INC. NPL SITE GRIFFITH, INDIANA	MONTGOMERY WATSON
Reference 4077.0110-A3			
Revisions			

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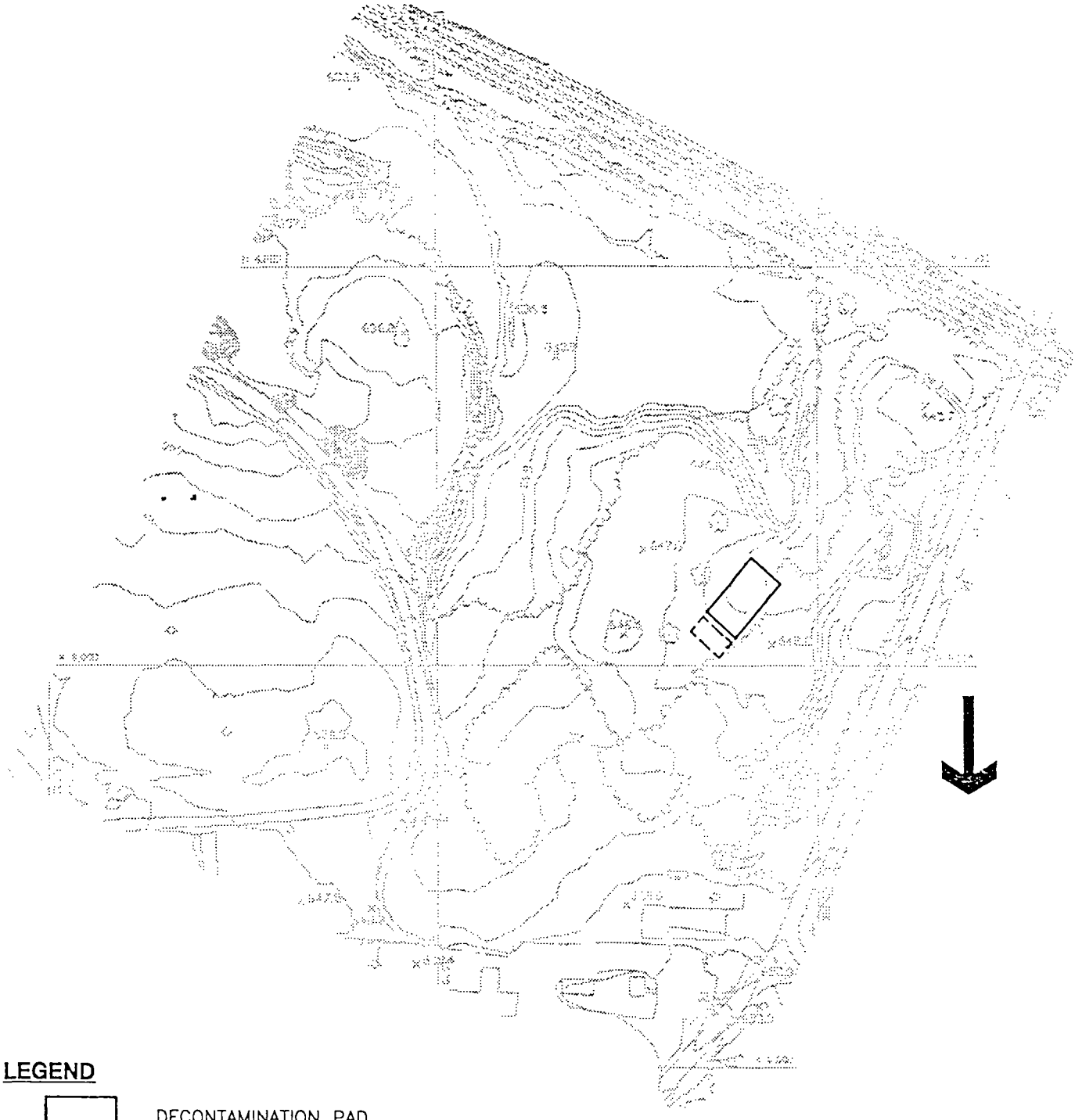

LEGEND

- DECONTAMINATION PAD
- SITE TRAILER AND SUPPORT ZONE
- RAILROAD TRACK
- TOPOGRAPHIC CONTOUR
- PREVAILING WIND DIRECTION

north

0 200 400

SCALE IN FEET

NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY MAP OF THE SITE FLOWN ON MARCH 8, 1994 BY GEONEX CHICAGO AERIAL SURVEY, INC.
2. VERTICAL DATUM IS U.S.G.S. DATUM. CONTOUR INTERVAL IS 2 FEET.

FIGURE 3-5

Developed By PMS/DAP, Drawn By TPB,LCL Approved By Date 8-18-95 Reference 4077.0110-A4 Revisions	**DECONTAMINATION PAD/SUPPORT ZONE LOCATION MAP (OFF SITE)** SITE HEALTH AND SAFETY PLAN AMERICAN CHEMICAL SERVICE, INC. NPL SITE GRIFFITH, INDIANA	Drawing Number 4077.0110 A61 MONTGOMERY WATSON	

Management Review
Other
Technical Review
Project Manager
Graphic Standar
Lead Professio
QUALITY CONTROL
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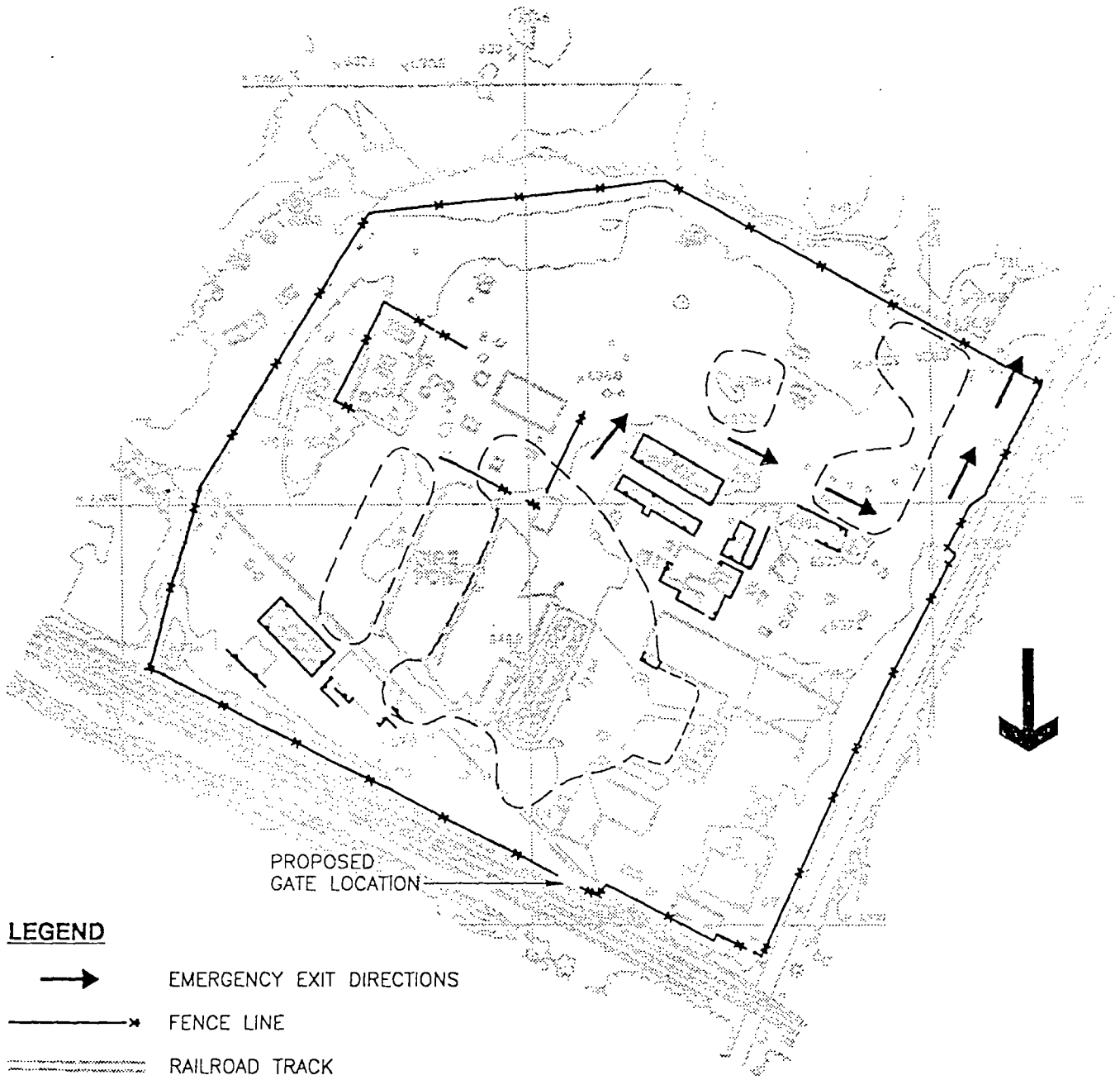

LEGEND

- EMERGENCY EXIT DIRECTIONS
- FENCE LINE
- RAILROAD TRACK
- TOPOGRAPHIC CONTOUR
- APPROXIMATE EXTENT OF KNOWN SOIL CONTAMINATION
- PREVAILING WIND DIRECTION

NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY MAP OF THE SITE FLOWN ON MARCH 8, 1994 BY GEONEX CHICAGO AERIAL SURVEY, INC.

2. VERTICAL DATUM IS U.S.G.S. DATUM. CONTOUR INTERVAL IS 2 FEET.

north

0 200 400

SCALE IN FEET

FIGURE 7-1

Developed By PMS,DAP Drawn By TMS,TPB,LCL

Approved By Date 5-14-95

Reference

Revisions

EMERGENCY EXIT ON-SITE CONTAINMENT AREA

SITE HEALTH AND SAFETY PLAN
AMERICAN CHEMICAL SERVICE, INC.
NPL SITE
GRIFFITH, INDIANA

Drawing Number 4077.0030 A64

MONTGOMERY WATSON

Management Review | Other
Technical Review | Project Manager
Graphic Standards | Lead Professional
QUALITY CONTROL

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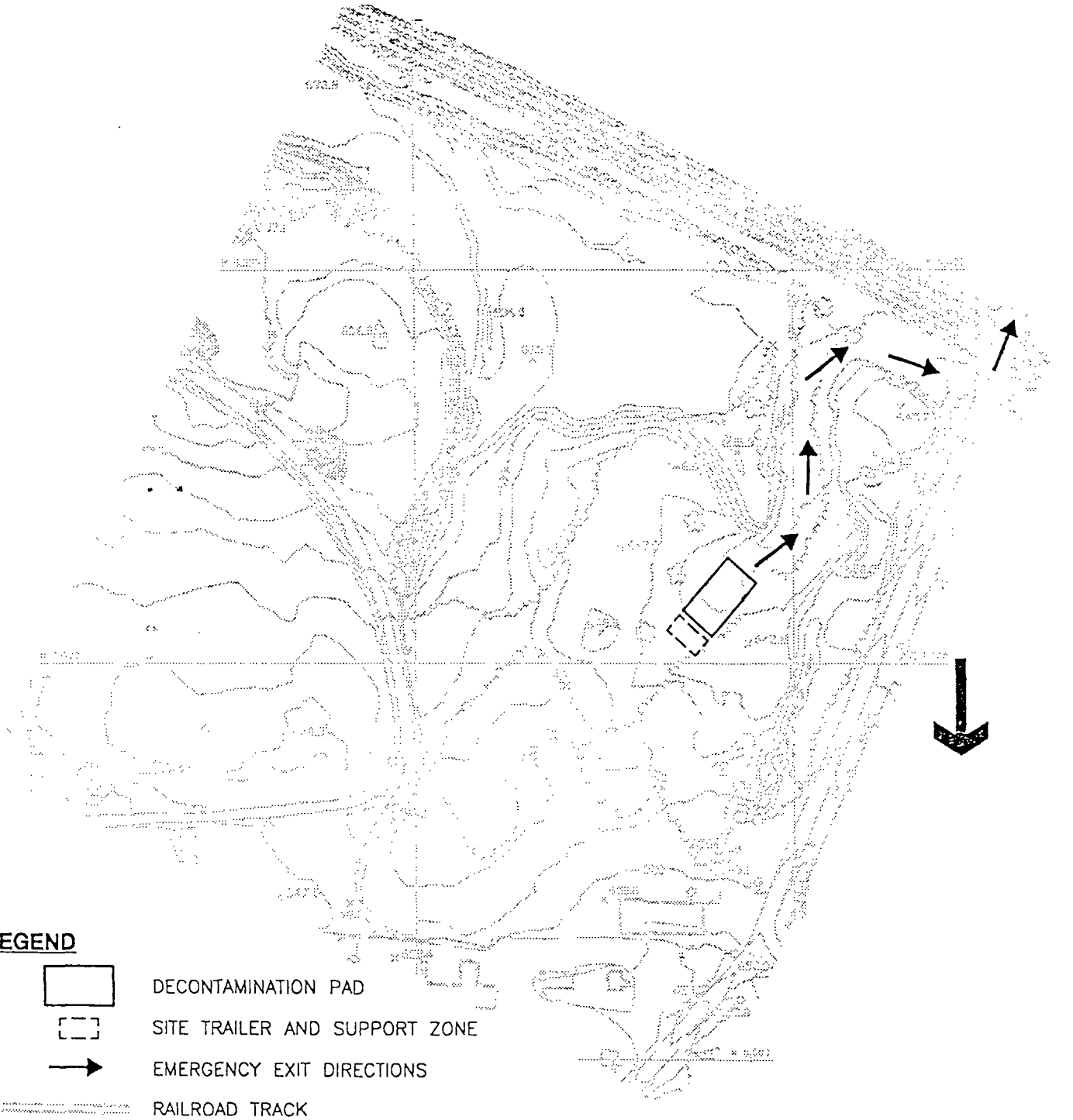

LEGEND

- DECONTAMINATION PAD
- SITE TRAILER AND SUPPORT ZONE
- EMERGENCY EXIT DIRECTIONS
- RAILROAD TRACK
- TOPOGRAPHIC CONTOUR
- PREVAILING WIND DIRECTION

NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY MAP OF THE SITE FLOWN ON MARCH 8, 1994 BY GEONEX CHICAGO AERIAL SURVEY, INC.
2. VERTICAL DATUM IS U.S.G.S. DATUM. CONTOUR INTERVAL IS 2 FEET.

north

0 200 400

SCALE IN FEET

FIGURE 7-2

Developed By PMS,DAP Drawn By TMS,TPB,LCL

Approved By [signature] Date 8-18-95

Reference

Revisions

EMERGENCY EXIT - OFFSITE CONTAINMENT

SITE HEALTH AND SAFETY PLAN
AMERICAN CHEMICAL SERVICE, INC.
NPL SITE
GRIFFITH, INDIANA

Drawing Number 4077.0030 A63

MONTGOMERY WATSON

Management Review: Other

Technical Review: Project Manager

QUALITY CONTROL: Graphic Standard: Lead Profession

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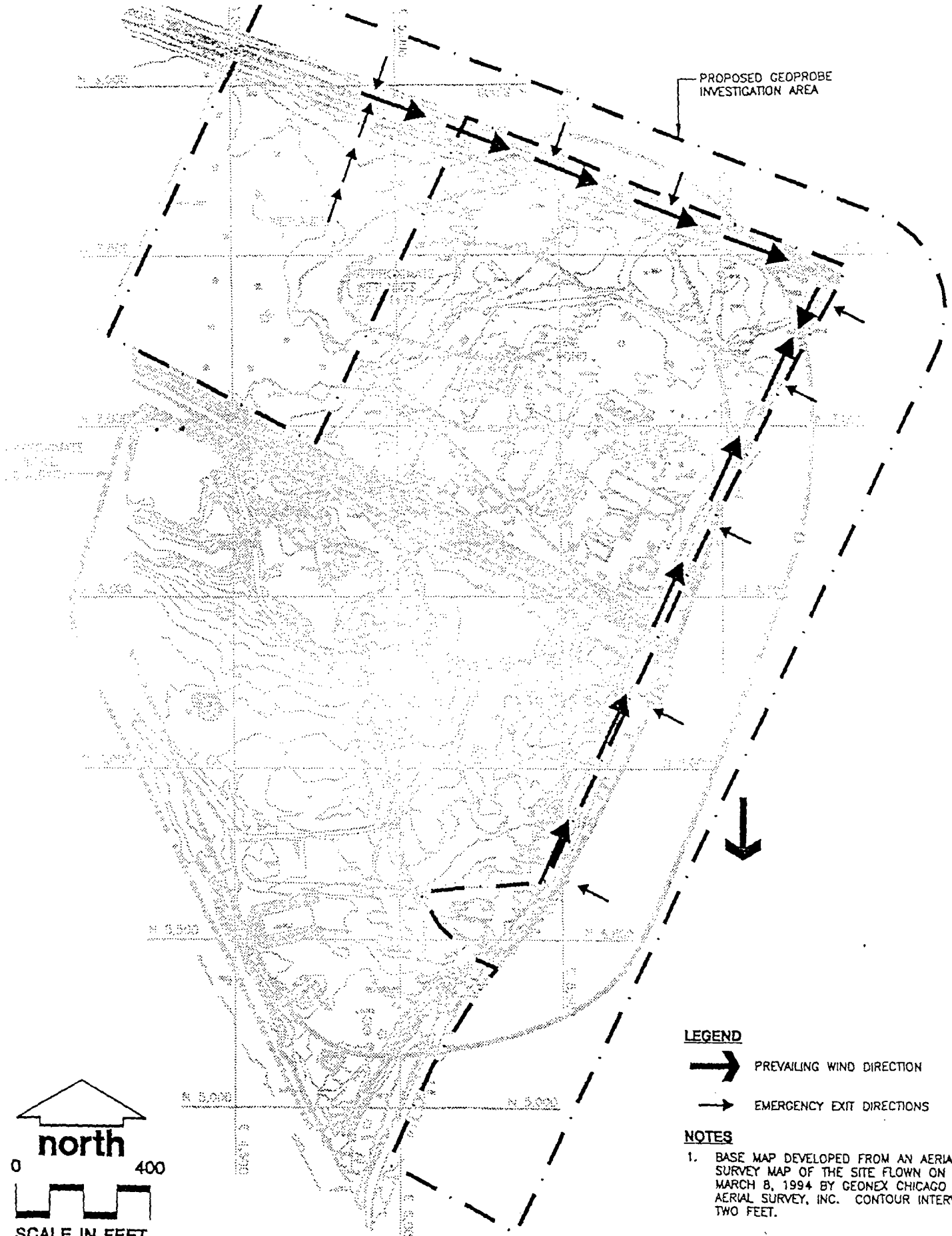

LEGEND

PREVAILING WIND DIRECTION

EMERGENCY EXIT DIRECTIONS

NOTES

1. BASE MAP DEVELOPED FROM AN AERIAL SURVEY MAP OF THE SITE FLOWN ON MARCH 8, 1994 BY GEONEX CHICAGO AERIAL SURVEY, INC. CONTOUR INTERVAL TWO FEET.

FIGURE 7-3

Developed By PMS,DAP,MJH Drawn By TMS,LCL,TPB

Approved By [signature] Date 8-16-95

Reference

Revisions

EMERGENCY EXIT FROM GEOPROBE GROUNDWATER INVESTIGATION AREA

SITE HEALTH AND SAFETY PLAN
AMERICAN CHEMICAL SERVICE, INC.
NPL SITE
GRIFFITH, INDIANA

Drawing Number 4077.0030 A65

MONTGOMERY WATSON

Management Review Other
Technical Review Project Manager
QUALITY CONTROL Graphic Standards Lead Profession
This document has been developed for a specific application and may not be used without the written approval of Montgomery Watson.

D

SEVERE WEATHER

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SEVERE WEATHER

When projects are conducted outside, the potential for severe weather must be considered. Thunderstorms, tornados, and winter storms can develop quickly, jeopardizing your safety. The following emergency procedures are to be followed in the event of severe weather.

THUNDERSTORMS AND LIGHTNING

Monitor weather conditions at all times while working. At a sign of an impending storm - increased cloudiness, darkened skies, increased wind - listen to a radio for the latest weather information.

When a thunderstorm accompanied by lightning is in the project area, cease work immediately. All powered equipment, such as drill rigs, are to be shut down.

Seek shelter inside nearby buildings or trailers. If there are no buildings nearby, seek shelter inside your vehicle.

If you are caught outside, do not stand beneath tall, isolated trees or telephone poles. Avoid areas projecting above the landscape such as hill tops. In open areas, go to a low place such as a ravine or valley. Stay away from open water, metal equipment, wire fences and metal pipes. If you are in a group of people in the open, spread out, staying several yards apart.

If you are caught in a level field or open area far from shelter and you feel your hair stand on end, lightning may be about to strike you. Drop to your knees and bend forward, putting your hands on your knees. You should minimize the body area in direct contact with the ground. Do not lie flat on the ground.

If someone has been struck by lightning, monitor life signs and begin administering mouth-to-mouth resuscitation or cardiopulmonary resuscitation as needed. Send for help.

Check conscious victims for burns, especially at the fingers and toes and next to buckles and jewelry. Administer first aid for shock. Do not let the victim walk around.

TORNADOS

Tornados usually develop from thunderstorms and normally occur at the trailing edge of the storm. Most tornados occur in the months of April, May, June, and July in the late afternoon and early evening hours.

When storms are predicted for the project area, monitor weather conditions on a radio. A tornado watch is issued when favorable conditions exist for the development of a tornado. A tornado warning is issued by the local weather service office whenever a tornado has actually been sighted or is strongly indicated by radar.

If a tornado warning is issued, seek shelter immediately. If there are permanent buildings located on site, go there immediately, moving toward interior hallways or small rooms on the lowest floor.

If a tornado warning is issued and you are in a vehicle or a site trailer, leave and go to the nearest building. If there are no buildings nearby, go in the nearest ditch, ravine or culvert, with your hands shielding your head.

If a tornado is sighted or a warning issued while you are in open country, lie flat in a ditch or depression. Hold onto something on the ground, such as a bush or wooden fence post, if possible.

Once a tornado has passed the site, site personnel are to assemble at the designated assembly area to determine if anyone is missing. Administer first aid and seek medical attention as needed.

WINTER STORMS

When snow or ice storms are predicted for the project area, site personnel should monitor weather conditions on a radio. A winter storm watch is issued when a storm has formed and is approaching the area. A winter storm warning is issued when a storm is imminent and immediate action is to be taken.

When a storm watch is issued, monitor weather conditions and prepare to halt site activities. Notify the project manager of the situation. Seek shelter at site buildings or leave the site and seek warm shelter.

If you are caught in a severe winter storm while traveling, seek warm shelter if road conditions prevent safe travel.

If you are stranded in a vehicle during a winter storm:

- Stay in the vehicle. Disorientation comes quickly in blowing and drifting snow.
- Wait for help.
- Keep a window open an inch or so to avoid carbon monoxide poisoning.
- Run the engine and heater sparingly.
- Keep watch - do not let everyone sleep at the same time.
- Exercise occasionally.

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TEMPERATURE STRESS

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TEMPERATURE STRESS

This section outlines the signs and symptoms of temperature stress in addition to the engineering controls, work practice controls and other management techniques that should be used to reduce temperature stress. Individual susceptibilities to temperature stress need to be considered and used to pace the work being performed with the most susceptible person controlling the work/rest schedule. Monitoring for heat stress is to be performed as detailed in this section.

COLD STRESS

Reduction

The following engineering controls are recommended for reduction of cold stress:

- Use general or spot heating to increase temperature at work site if this does not create a hazardous situation.
- Shield work area from wind.
- Cover metal handles of tools and equipment with thermal insulating materials.
- Do not sit on unprotected metal chair seats.
- Use heated rest areas if work is to be performed in an equivalent chill temperature of 20° F or below.

The following work practice controls are recommended to reduce cold stress:

- Drink warm, caffeine-free, sweet, non-alcoholic drinks or soup frequently.
- Schedule work for warmest part of the day.
- Use heated rest areas regularly.

- Use the buddy system. Do not work alone. Observe your co-workers for signs and symptoms of cold stress.

- Allow and encourage workers to pace themselves and take extra breaks when needed. The work schedule should be set by the person most susceptible to cold stress. Do not pressure someone to work beyond their capabilities.

- Whenever possible, allow new workers time to adjust to working in a cold environment before working full time. Ideally, acclimation should occur over five days: 20% Day 1 with a 20% increase on each successive day.

- When possible, arrange the work to minimize standing or sitting still for long periods of time.

- Reorganize work procedures so as much of a job as possible can be done in a warm environment.

- Avoid overtime.

- Remove outer layer of clothing when entering warm shelter.

- If clothes are wet, change to dry work clothes before returning to work in cold. If not possible, loosen clothing to facilitate evaporation of sweat.

- Develop and adhere to a work-rest schedule, using the guidelines which follow.

Air Temperature with Sunny Sky (degrees F)	Work/Break Schedule (minutes)				
	no wind	5 mph wind	10 mph wind	15 mph wind	20 mph wind
-15 to -19	110/10	110/10	75/10	55/10	40/10
-20 to -24	110/10	75/10	55/10	40/10	30/10
-25 to -29	75/10	55/10	40/10	30/10	cease
-30 to -34	55/10	40/10	30/10	cease	cease
-35 to -39	40/10	30/10	cease	cease	cease
-40 to -44	30/10	cease	cease	cease	cease
-45 & below	cease	cease	cease	cease	cease

Notes

1. These recommendations and guidelines are adapted from Threshold Limit Values and Biological Exposure Indices for 1993-1994, published by the American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

2. 05 mph wind - light flag moves, 10 mph wind - light flag fully extended, 15 mph wind - raises newspaper sheet, 20 mph wind - blowing and drifting snow

The practicality of working under a work-rest schedule, together with the ability of the necessary equipment to function properly in cold weather, may be more restrictive than the health hazards and also need to be considered. The cold stress schedules noted above apply to moderate to heavy work activities. Light to moderate work activities can be moved down one level.

Signs and Symptoms
Send a worker to warm shelter immediately if any of the following symptoms are noted:

- Heavy shivering
- Frostnip (skin turns white)
- Feeling of excessive fatigue
- Drowsiness
- Euphoria

First Aid
Take victim to a warm area. Remove the outer layers of clothing. Gently warm the affected area, submerge it in tepid water if possible but do not rub. If there is evidence of frostbite, obtain medical attention immediately.

HEAT STRESS

Reduction
While site specific conditions need to be considered, the following guidelines are recommended to prevent or reduce the effects of heat stress.

- Develop and adhere to a work-rest schedule using the guidelines at the end of this section.

- Take breaks in cool areas.

- Drink fluids hourly. The fluids should be caffeine-free and non-alcoholic. Water or electrolyte-replacement drinks, such as Gatorade™, are good choices. Do not wait until you are thirsty. Your normal thirst mechanism is not sufficient to overcome the effects of dehydration. If you feel thirsty, you are already becoming dehydrated.

- Schedule work for the cooler part of the day -- early morning and/or early evening.

- Allow and encourage workers to pace themselves and take extra breaks when needed. The work schedule should be set by the person most susceptible to heat stress. Do not pressure someone to work beyond their capabilities.

- Whenever possible, allow new workers time to adjust to working in a hot environment before working full time. Ideally, acclimation should occur over five days: 20% Day 1 with a 20% increase on each successive day.

- Avoid overtime.

- Use the buddy system. Never work alone and watch your co-workers for signs of heat stress.

Personal Monitoring
At each work break, count your pulse during a 30 second period as early as possible in the rest period.

- If your heart rates exceeds 110 beats per minute (BPM) at beginning of rest period, shorten your next work cycle by 1/3 and keep the rest period the same.

- If your heart rate still exceeds 110 BPM at that next rest period, shorten the following work cycle by 1/3.

At the beginning and end of each work shift, measure your weight, $\pm$ 0.25 LB, wearing similar clothes. You should not lose more than 1.5 % of your total body weight in a work day. If you do, drink fluids to compensate and to prevent dehydration.

A summary of recommended work breaks and personal monitoring schedule follows. These values apply to moderate work levels. For heavy work levels, apply monitoring schedule one level up. Light to sedentary work activities can be moved down one level if workers are acclimated and show no signs of heat stress.

	Heat Stress Monitoring (min)	
Adjusted Temperature* (°)	**Normal Work Clothes**	**Impermeable Work Clothes**
above 90	45	15
88 to 90	60	30
83 to 87	90	60
77 to 82	120	90
72 to 78	150	120

* Adjusted temperature = measured temperature + (13 x % sunshine)

Note

1. These recommendations and guidelines are adapted from Threshold Limit Values and Biological Exposure Indices for 1990-1991, published by the American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

Signs and Symptoms

- Heat rash

- Heat cramps: Muscle spasms; pain in hands, feet or abdomen

- Heat exhaustion: Pale, cool, moist skin; heavy sweating; dizziness; nausea; fainting

- Heat stroke: Red, hot, usually dry skin; lack of, or reduced, perspiration; nausea; dizziness; confusion; strong, rapid pulse; coma

First Aid

Remove the affected individual's protective clothing and equipment. Wrap the victim in wet towels or clothing. If there are signs or symptoms of heat exhaustion or heat stroke, get medical attention immediately.

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General Health and Safety Rules

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GENERAL HEALTH AND SAFETY RULES

Certain rules and regulations apply to specific Montgomery Watson Operations. Personnel will follow these procedures when performing the specified tasks or work in the designated area.

SAFETY RULES WHEN WORKING NEAR HIGHWAYS OR CONSTRUCTION SITE TRAFFIC

Set out traffic cones, warning signs, and flashers when performing field work in traffic areas. In traffic areas and on construction sites where heavy equipment is operating, wear luminous traffic vests.

Wear safety vests when working closer than 10 ft from a roadway.

Use safety signs when performing bridge and highway surveys and use warning lights on vehicles, as appropriate.

Let the construction equipment operators know you are around. Have "eye to eye" contact prior to setting up for a test.

Check the traffic pattern on construction projects before entering with a Montgomery Watson vehicle.

Stay away from the swing of the back-hoe bucket.

If practical, use your vehicle on a large site to divert construction traffic around the test area.

Park the testing vehicle between your work area and the operating equipment. Always work a significant distance behind your vehicle to allow for it being struck.

SAFETY RULES FOR HAZARDOUS WASTE SITES

Smoking is not permitted at the site or in the site trailer.

Eating and drinking are only permitted in the support or clean zone.

Secure all loose equipment in the test vehicle which might "fly" when making sudden stops.

No open fires are allowed.

All employees handling hazardous waste samples or who may be exposed to hazardous or solid waste must be active participants in the medical surveillance program.

A respirator can not be worn when beards or any other facial hair interferes with the face-to-respirator seal. Individuals with such facial hair are not to be allowed to work in Level of Protection C or B.

Working alone on field sites is generally prohibited. The "buddy system" is to be enforced at all times unless the Health and Safety Coordinator (HSC) specifically exempts the work from his requirement, based on the HSC's review of site conditions and hazards. When working under the "buddy system", personnel are to:

- Never work alone
- Provide partner with assistance
- Observe partner for signs for overexposure/temperature stress
- Check integrity of partner's protection clothing
- Notify others if emergency help is needed

Personnel on site must use the buddy system when wearing respiratory protective equipment. Visual contact must be maintained between pairs on-site. Entry team members are to remain close together to assist each other during emergencies.

No "souvenirs" or samples not required for the project are to be collected.

Samples are to be placed in approved containers before they can be removed from the site. Only approved or designated vehicles can be used to transport samples.

Samples are to be left in the staging area. Samples are never to be brought into the office.

Field apparel that had not been decontaminated is not to be worn into the office.

Field samples are to be disposed properly.

Observe all safety signs and do not remove any "lockout tags" or other lockout devices.

Contact with contaminated or suspected contaminated surfaces is to be avoided.

Do not walk through puddles, discolored surface, kneel on the ground, or lean, sit, or place equipment on visibly stained surfaces.

Drums or tanks found on site are not to be opened or moved unless specific drum/tank remediation tasks are specifically included in the SSP and are fully implemented.

Use work schedules that minimize time spent in hazardous areas.

Use work assignments that place employees upwind of sources of air contaminants.

Post the Site Safety Plan, or have a copy readily available, for review by employees. Verify that all personnel have read and signed the SSP.

Notify the SSO of any unsafe acts or conditions or at the first indication that you experience temperature stress or signs and symptoms of possible chemical exposure.

LADDER SAFETY

Ladders pose a significant hazard when improperly used or maintained. There are four causes of accidents involving ladders. They include:

- Improperly securing ladder top and/or bottom
- Structural failure of ladders
- Ascending or descending ladders improperly
- Carrying objectives when ascending or descending ladders

Step Ladders

Step ladders must have positive locking spreaders which will fully spread and lock when the ladder is in use.

- Do not use a step ladder as a straight ladder.
- Do not use the top two steps of a step ladder.
- Do not climb the cross-bracing on the rear side of stepladders.

Straight Ladders

Portable manufactured straight ladders will be used by Montgomery Watson. Job-built ladders require special regulations and will not be used by Montgomery Watson employees unless approval is given by the Health and Safety Manager.

- When portable ladders are used for access to an upper landing surface, the side rails must extend at least 3 feet above the upper landing surface. The ladder must be secured, and a grasping device, such as a grab rail, must be provided to assist workers in mounting and dismounting the ladder.

- Ladders must be maintained free of oil, grease, and other slipping hazards.

- Ladders must not be loaded beyond the maximum intended load for which they were built, nor beyond their manufacturer's rated capacity.

- Ladders must be used only for the purpose for which they were designed.

- Non-self-supporting ladders must be used at an angle where the horizontal distance from the top support to the foot of the ladder is approximately one-quarter of the working length of the ladder.

- Ladders must be used only on stable and level surfaces unless secured to prevent accidental movement.

- Ladders must not be used on slippery surfaces unless secured or provided with slip-resistant feet to prevent accidental movement. Slip-resistant feet must not be used as a substitute for the care in placing, lashing, or holding a ladder upon slippery surfaces.

- Ladders placed in areas such as passageways, doorways or driveways, or where they can be displaced by workplace activities or traffic, must be secured to prevent accidental movement, or a barricade must be used to keep traffic or activities away from the ladder.

- The area around the top and bottom of the ladders must be kept clear.

- Ladders must not be moved, shifted, or extended while in use.

- Ladders must have nonconductive siderails if they are used where the worker or the ladder could contact exposed energized electrical equipment.

- Ladders must be inspected by a competent person for visible defects on a periodic basis and after any incident that could affect their safe use.

- Single-rail ladders must not be used.

- When ascending or descending a ladder, the worker must face the ladder.

- Each worker must use at least one hand to grasp the ladder when moving up or down the ladder.

- A worker on a ladder must not carry any object or load that could cause the worker to loose balance and fall.

Other Procedures

- Don't reach beyond a normal arm's length sideways when working on a ladder. A good rule of thumb is to "keep your belt buckle between the side rails." Move the ladder as often as necessary to get close to the work.

- When extending extension ladders, keep your hands on the rails, not the rungs to prevent injuring your hands. Be sure the interlocking guides and connecting mechanisms are set and securely latched.

- Tools should not be left hanging or dangling from ladders or ladder rungs.

FALL PROTECTION

OSHA requires fall protection when the distance from a working surface to a lower level is more than six (6) feet. Fall protection may be required for distances less than six (6) feet if there are obstructions or other hazards present. The Montgomery Watson Site Safety Officer will be responsible for implementing fall protection procedures during field activities.

A fall protection system consists of four components - an anchorage point, a lanyard, a body support, and associated connectors.

Anchorage Point

Anchorage points for fall protection systems must be able to withstand 5,400 lbs static load strength for a 6 ft fall or 3,000 lbs for a 2 ft or less fall. The anchorage point should be directly overhead of the worker to prevent horizontal swing in the event of a fall.

A horizontal lifeline is a cable rigged between two fixed anchorage points on the same level and independent of the work surface. Horizontal lifelines are used when there are no anchorage points above the work area. A horizontal lifeline system requires careful engineering and will not be used without authorization of the Montgomery Watson Health and Safety Manager.

Lanyards

A lanyard is a short, flexible rope, or strap webbing used to connect a worker's safety harness to the anchorage point. Lanyards should have a minimum strength of 5,000 lbs and absorb the shock of a free fall of 6 ft or less. Shock absorbing lanyards are also available that absorb the energy of a free fall and decelerate the fall of the worker.

It is Montgomery Watson policy to purchase manufactured lanyards. Home made lanyards or ropes and tire-offs not allowed.

When attaching a lanyard to an anchorage point special crossover straps, or tie off adapters will be used. These are webbed straps with a D-ring on each end: The strap is looped around a pipe, beam or other anchor and the lanyard in anchored into both D-rings. Looping a lanyard around the anchor and hooking back onto itself is not permitted.

Self-Retracting Lifelines

Self-retracting lifelines are portable devices which are fixed to an anchorage point above a work area and plays out or retracts line automatically as workers move away and toward the device. When a fall occurs, a locking device automatically arrests movement. This type of device should be used in conjunction with tripod/winch devices during confined space entry.

Body Harness
A body harness is a web belt system designed to spread the shock from a fall over the entire body. A full body harness is required for all Montgomery Watson operations requiring fall protection systems. A body belt which is worn around the waist and chest harnesses are not permitted.

Hardware Connectors
Hardware connectors consist of D-rings, snap-hooks and metal links used to connect fall protection systems together. Connectors should be corrosion-resistant and all surfaces and edges should be smooth to prevent damage to interfacing parts. D-rings and snap-hooks should be able to withstand 5,000 lbs static loads and 3,600 proof tested pounds without cracking, breaking or sustaining distortion.

Montgomery Watson policy is to only use snap-hooks with a positive locking device or spring loaded keeper which prevents "roll-out" or unintentional release of components.

Additional Requirements
Lifelines, lanyards and harnesses should be protected from sharp edges or cutting edges such as along the edge of "I" beams. A webbing material should be used in these cases.

Knots reduce the strength of ropes, lanyards and cable by as much as 50%. Standard manufactured components will be used and employees will not use knots in fall protection systems.

A lanyard should not be connected to a harness and a deceleration device such as a retractable lifeline since the maximum fall distance of 6 ft maybe exceeded.

When work is performed in an aerial lift device such as a "cherry picker", workers must wear a harness and lanyard. The lanyard should be attached to the lift device bucket. Never attach the lanyard to anything outside the bucket.

Safety belts, lanyards and lifelines must only be used for employee protection. They are never to be used for lifting static loads.

Once used to arrest a fall, the fall protection equipment must be taken out of service and destroyed unless the equipment is inspected by the Site Safety Officer and deemed safe for reuse. Lanyards will always be destroyed after use. The SSO will document that the equipment was inspected and deemed safe for reuse in the field loghook.

Maintenance
Wipe off surfaces of fall protection lanyards, harnesses and connectors to remove gross contamination. Materials can be cleaned with soap and water. A soft brush can be used to scrub the equipment. Hang freely to dry. Do not use solvents or abrasive materials to clean the equipment.

Inspections
The SSO will inspect fall protection equipment each day before use. Document the inspection in field log books.

- Check lanyards for knots, cuts, fraying, chemical degradation. Rotate the lanyard and check the entire surface for damage. Make sure spliced connections are tight and secure.

- Inspect harness for damage including cuts, fraying, and chemical degradation. Make sure buckles and rings are not damaged.

- Inspect hooks for corrosion, dirt, and physical damage. All snap-hooks must fully close and lock. Visually check and physically test the hook. Do not rely on the sound of the hook closing.

- Inspect the tripod for damage. The unit should stand firmly when legs are extended. All bolts should be tight. Winch attachment bolts should be tight. Legs should not be bent and foot pads should be in place. Check winch to make sure ratchet system functions when crank is turned. Pull the line from the winch and make sure brake mechanism works properly.

- All broken, damaged or questionable lifelines, lanyards, harnesses and hooks should be taken out of service and be replaced.

  Contact the Office Supervisor, Warehouse Coordinator or Health and Safety Manager if defective parts are found, Do Not Use Damaged Equipment.

NUCLEAR DENSITY GAUGE SAFETY

Personnel who use nuclear density gauges (Troxler gauge) must follow specific procedures and regulations as required by Montgomery Watson's nuclear material license and the Nuclear Regulatory Commission (NRC). Gauges will be used, transported and stored according to these regulations.

The Troxler Nuclear Density Gauges emit two types of radiation which is a hazard for those working with the gauges.

Gamma Radiation
Gamma radiation is a form of electromagnetic radiation, as are x-rays, radio waves, and visible light. Gamma rays have no mass, zero electrical charge, travel at the speed of light and are much more energetic and penetrating than visible light. The more penetrating gamma rays are able to pass through solids. Gamma rays originate from the product nucleus after radioactive decay and are characteristic of a particular disintegration scheme. The gamma ray emitted after the decay of Cesium-137 to Barium-137 in the Troxler gauges can be stopped by several inches of lead.

Neutron Radiation

Neutron radiation used by Troxler gauges is produced by bombarding beryllium with the alpha particles produced by the decay of Americium-241. The interaction of an alpha particle with a beryllium atom produces an unstable isotope of carbon. The natural decay process that allows the carbon atom to reach a stable state requires the release of a neutron from the carbon nucleus.

The neutron, having no electrical charge, is very penetrating. The problem of shielding against neutrons is twofold: first they must be slowed down, then another material must be used to absorb the slowed neutrons. This slowing process, called thermalization, is best achieved by particles of the same mass as the neutron such as hydrogen. Water as well as other materials with high hydrogen content are ideal thermalizers. Boron and cadmium are particularly good thermal neutron absorbers. Therefore, shielding is accomplished by placing polyethylene, a material with a high hydrogen content, around the neutron source to thermalize the neutrons, allowing them to be absorbed by a thin cadmium sheet covering the polyethylene.

Exposure Limits

Current OSHA allowable exposure limits are 5 rem/year - whole body. The NRC requires that the dose to an embryo fetus during an entire pregnancy be less than 0.5 rem. Women who use nuclear density gauges should declare their pregnancy to the Radiation Safety Officer (RSO) at the earliest possible date so that this exposure limit is not exceeded.

Staff certified to use the Troxler gauges will be issued radiation badges monthly. Montgomery Watson radiation badges measure gamma rays, beta particles, x rays and fast neutrons. Personnel who are not issued radiation badges will not be allowed to use the gauges. Landauer reports of radiation exposure are in millirems. 5,000 millirems = 5 rem annual exposure limit. Each quarter personnel with radiation badges will be given a copy of their exposure record.

PRINCIPLES OF RADIATION PROTECTION

There are three factors that effect radiation exposure:

- Time - The less time a person remains in the area of radiation the less radiation dose received.

- Distance - The intensity of radiation falls off as the inverse square of the distance from the source. By moving twice as far from the source, exposure to radiation is reduced to 1/4 the level. Moving three times as far away reduces exposure to 1/9 the level.

- Shielding - Protective material placed between the user and the source reduces exposure. In the gauges, this is accomplished by keeping the sources in the "locked" or shielded position when not in use.

General Procedures

- Never use or manipulate a gauge without proper training, knowledge, or authorization.
- Wear a radiation badge when working with a gauge.
- Advise other workers to stay clear when the gauge is in use.
- Only the manufacturer should attempt to repair the source, source holder, or shutter.
- Always lock the shutter in the "off" position until maintenance is completed.
- Avoid any physical contact with, or direct exposure to the source when performing maintenance.
- Clean the gauge once or twice a week to prevent dirt form getting near the shutter.
- If necessary, clean the area around the shutter throughout the day if conditions are extremely muddy.
- Make sure the gauges are leak tested every six months.
- Before storing, make sure the source is in the safe position.
- Lock the source and shutter in place.
- Never modify the source holder, shielding, or safety interlocks.
- Store the gauge in its case when not in use.
- Never leave the gauge unattended at a job site.
- Identify the case in case it is lost, damaged or misplaced.
- Lock the area where the gauge is stored.
- When taking a gauge to and from a job site, place it in its case and keep it in an unoccupied part of the vehicle. The case should be locked and chained to the vehicle. The chain should be locked as well.
- Ship according to DOT requirements.

WORKING NEAR WATER

Employees working near water, where a danger of drowning exists will wear U.S. Coast Guard approved life jackets. The SSO will inspect life jackets before and after each use. Defective life jackets will be taken out of service and destroyed. When working from boats or barges ring buoys with at least 90 ft of line will be available for emergency use. A lifesaving skiff will be available when working from barges for rescue purposes.

ELECTRICAL SAFETY

Montgomery Watson employees will not perform electrical installations or work on energized electrical equipment where "live" parts are exposed. Energized electrical equipment should be deenergized before performing maintenance.

Electrical Cords
Electrical cords passing through work areas should be covered or elevated to protect the cord from damage and reduce hazards to employees.

Extension cords used with portable tools will be 3-wire type and will be protected from damage when in use. Extension cords must be inspected on a routine basis. Cords with cuts in the insulation or that are worn or frayed or have insulation pulled back from the plug or receptacle fittings will be taken out of service immediately.

Grounding
Portable tools and other electrical equipment will be grounded or double insulated. Ground fault circuit interrupters (GFCIs) will be used in wet areas and on all field sites and outdoor operations. Extension cords used on field sites must always be used in conjunction with GFCIs.

HOT WORK

Hot work involves the use open flames or other sources of heat around possible sources of flammable vapors. Hot work includes:

- Welding
- Burning or cutting with a torch or saw
- Grinding
- Using impact tools that create sparks
- Any other operation that is a potential ignition source in the presence of flammable vapors

These procedures are designed to control sources of ignition and reduce fire and/or explosion hazards of the operations.

Operations defined as hot work outlined above are not allowed unless they are expressly addressed under the scope of work in the health and safety plan. When hot work procedures are permitted under the scope of work, the SSO will be responsible for implementing fire control measures, they include:

- Designating a fire watcher to monitor hot work practices.
  - The fire watcher will monitor operations and have a fire extinguisher at the ready for emergencies. The fire watcher will know how to sound an alarm and how to evacuate the area.
  - Fire watchers cannot perform other tasks during hot work procedures.
  - Fire watchers should only try to extinguish fires that are within their capacity.
  - Fire watches should be maintained for at least one-half hour after a welding or cutting operations to detect and extinguish smoldering fires.
- Having the right type and size of fire extinguisher for the job in question.
- Using air monitoring equipment including combustible gas indicators and oxygen monitors to maintain explosive vapors at safe levels.
- Using necessary purging/inerting procedures to reduce accumulation of flammable vapors.

UNDERGROUND STORAGE TANK (UST) REMOVAL

The following general procedure will be used for UST removal.

Initial Preparation

- Roads in the work area should be barricaded and caution tape or portable fencing used to limit access to the work area.
- Ignition sources will be removed from the work area. These include smoking, welding, all electrical equipment and internal combustion engines.
- A fire extinguisher of adequate type and size for the operation will be placed within 20 ft of operations.

Product lines should be disconnected and drained and pumps and electrical equipment removed and disconnected. The top of the tank should then be excavated. Tank contents will be removed by pumping with an explosion proof mechanical or pneumatic pump. Product will be placed in 55 gallon drums. The pump lines and hoses should be bonded to the UST and to the 55 gallon drum to prevent build-up of static charges.

Inerting/Purging

One the tanks are empty of free product, they will be inerted by placing dry ice through a fill pipe opening or by pumping nitrogen to the bottom of the tank. At least 1.5 pounds of dry ice per 100 gallons tank capacity is required. The dry ice should be crushed and evenly distributed (as much as possible) to promote rapid evaporation. As carbon dioxide or nitrogen displaces tank vapors, toxic vapors will be expelled through the vent. All other openings should be sealed to prevent air from entering the tank. Vapors should be vented 12 ft above grade by extending the vent pipe. An organic vapor monitor will be used to measure toxic vapor concentrations in the breathing zone of workers in the area. Oxygen and combustible gases will be monitored during the inerting process. When the oxygen level is less than 5%, the tanks will be excavated and staged for cleaning. (LEL readings will not be reliable when the tank is inerted due to insufficient oxygen for combustion.) Oxygen and LEL should be monitored frequently during all operations to ensure inert conditions are maintained. When taking readings, drop a tube connected to the LEL/Oxygen meter into the tank and measure levels at the bottom, middle and upper tank levels.

An alternative method of purging involves placing an eductor-type air blower driven by an air compressor on the fill (drop) pipe to draw fresh air in through another tank opening. The blower must be installed on the drop pipe so vapors are removed from the bottom of the tank. Fresh air is drawn into the top of the tank at the other opening. The blower must be properly bonded to the tank and grounded to prevent the build-up of static charge.

Cutting

To prepare for opening the tanks, each tank will be grounded by attaching conductive cable to the tank. The other end of the cable will be attached to a grounding rod driven into the ground. An abrasive chop saw or pneumatically driven rivet buster will be used to cut off both ends of the tanks. If the rivet buster is used, two operators are required to man the device. In addition, a fire spotter with the fire extinguisher at the ready is required until the tank cutting operation is completed. For smaller tanks, under 1,000 gallons, the entire end of the tank will be removed creating a square whose corners reach the edge of the tank. For larger tanks the opening must be at least 4 ft by 4 ft to prevent the tanks from being classified as a confined space. Monitor oxygen and LEL levels throughout the process to ensure inert or purged conditions are maintained. Add more dry ice or keep pumping nitrogen into the tank during cutting. If the eductor blower method of purging is used, the blower should be run continuously through the cutting operation.

Cleaning

Once the ends of the tanks are removed, thus eliminating the tank as being classified as a confined space, personnel may enter to perform cleaning operations. Oxygen, LEL and organic vapors must be monitored before entry. If the tank was inerted with dry ice or nitrogen, the eductor blower will now be placed on the tank to purge these gases and bring

oxygen levels to the acceptable range. Personnel will don Level C or Level B protection and clean the tank. Level C is used for fuel oils or diesel fuel. Level B is required when entering any tank that contained gasoline due to the possible presence of tetraethyl lead. The eductor blower will be in operation at all times during the cleaning process.

LIFTING/MATERIALS HANDLING

Back injuries are a primary workplace safety problem. Common sense and preplanning can prevent most back injuries.

Material Handling

- Inspect materials for silvers, jagged or sharp edges, burrs, rough or slippery surfaces.
- Grasp the object with a firm grip.
- Keep fingers from pinch and shear points, especially when setting materials down.
- Wipe off greasy, wet, slippery, or dirty objects before handling them.
- Keep hands free form oil and grease.
- Use leather or cloth gloves to protect hands.

Preparation For Lifting and Carrying

Before starting to lift or carry anything, check your entire walkway to make sure your footing will be solid. Your shoes should give you good balance, support and traction.

- Clear any moveable obstacles out of the way, and make sure you know the location of immovable ones.

- Cautiously heft the object to be moved to check its weight and center of gravity.

Lifting Procedure

- Get a firm footing. Keep your feet apart for a stable base; point toes out.

- Bend your knees. Don't bend at the waist. Keep the principals of leverage in mind. Don't do more work than you have to.

- Tighten you stomach muscles. Abdominal muscles support the spine offsetting the force of the load.

- Lift your legs. Let your powerful leg muscles do the work of lifting, not your weaker back muscles.

- Keep the load close. Don't hold the load away form your body. The closer it is to your spine, the less force it exerts on you back.

- Keep your back upright. Whether lifting or putting down the load; don't add the weight of your body to the load.

Safety Tips for Lifting

- Don't lift objects over your head.
- Don't twist your body when lifting or setting an object down.
- Don't reach over an obstacle to lift a load. Move the obstacle or go around it.
- Pace yourself to avoid fatigue when doing heavy work for long periods.
- Use common sense.

Alternative To Lifting
For difficult lifting tasks, keep the following in mind.

- Ask a co-worker for help.
- Use a cart or other material handling device.

Pushing a load is easier on the back than pulling it. When pushing a load:

- Stay close to the load.
- Don't lean forward.
- Use both arms.
- Keep the stomach muscles tight.

If you must pull something:

- Face the object squarely, with one foot at least 12 in. in front of the other.
- Keep your back straight.
- Bend your knees slightly.
- Pull with one smooth motion.

Shoveling
General lifting procedures also apply to shoveling. Use the following procedure:

- Make sure your grip and balance are solid.
- Tighten you abdomen as you lift.
- Keep the shovel close to your body.
- Bend your knees not your back.
- Use the strength of the thighs to bring you to an upright position.
- Increase you leverage by keeping your bottom hand low and toward the shovel blade. This allows you to use the strength of your arms and shoulders instead of your back.

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DECONTAMINATION

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DECONTAMINATION

Everything leaving the exclusion zone must be decontaminated or properly discarded. The exclusion zone is to be defined in the Site Health and Safety plan. All personnel entering the exclusion zone must exit through the decontamination zone. All equipment is to be decontaminated and inspected before it is moved into the support zone. Decontamination solutions are to be appropriate for the hazards. Decontamination solutions are to be changed at least daily and stored on site until disposal arrangements are made. Any material generated by the decontamination procedures will be stored in a designated area in the exclusion zone until disposal arrangements are made.

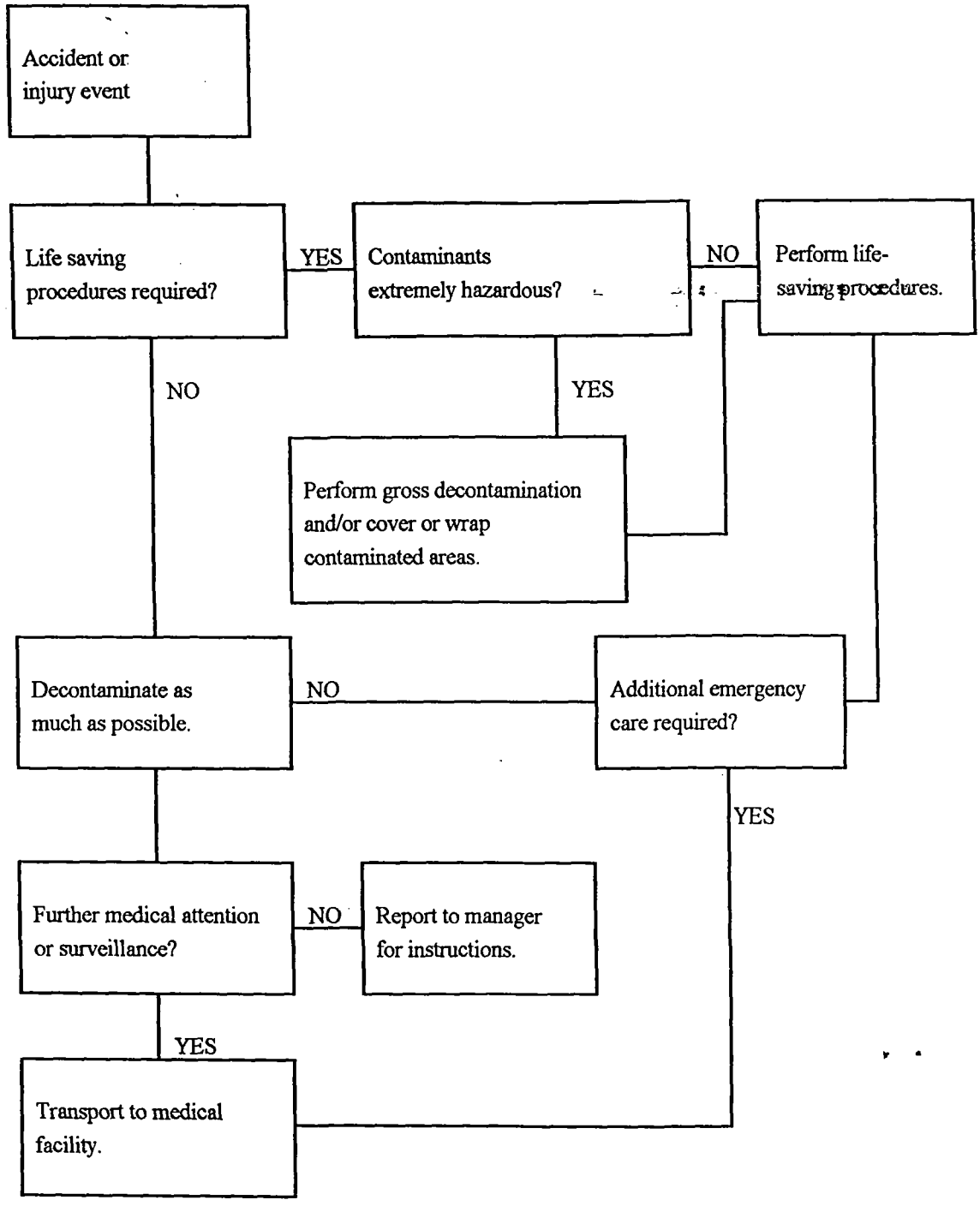
EMERGENCY DECONTAMINATION

The need for emergency decontamination of an individual may arise as the result of:

- Injury or illness
- Overexposure to chemicals or hazardous substances
- Temperature stress

Primary consideration needs to be given to life-preservation actions and the minimization of additional harm or health risks to the individual in the emergency situation and the rescuing individuals.

EMERGENCY DECISIONS



LEVEL B ROUTINE DECONTAMINATION

Equipment Drop
Deposit equipment used on site (tools, sampling devices, monitoring equipment, radios, etc.) on plastic drop cloths. Decontaminate or dispose of items before removal from exclusion zone.

Outer Boot/Glove Wash and Rinse
Scrub outer boots/gloves with decontamination solution then rinse with water.

Outer Boot/Glove Removal
Remove outer boots/gloves:

- If outer boots/gloves are disposable, deposit them in the appropriate plastic-lined container.
- If outer boots/gloves are not disposable, store them in a clean, dry place.

Outer Garment Removal
If using self-contained breathing apparatus (SCBA), remove SCBA back pack and remain on air as long as possible. Remove chemical-protective outer garments and deposit in the appropriate container.

Respiratory Protection Removal
Remove hard hat and face piece, and deposit on a clean surface. Wash and rinse hard hat and face piece. Wipe off and store face piece in a clean, dry location.

Inner Glove Removal
Remove inner gloves and deposit in the appropriate container for disposal.

Field Wash
Thoroughly wash hands and face with soap and water. Shower as soon as possible.

LEVEL B DECONTAMINATION FOR AIR TANK EXCHANGE

Equipment Drop
Deposit equipment used on site (tools, sampling devices, monitoring equipment, radios, etc.) on plastic drop cloths. Decontaminate or dispose of items before removal from exclusion zone.

Outer Boot/Glove Wash and Rinse
Scrub outer boots/gloves with decontamination solution then rinse using water.

Outer Boot/Glove Removal
Remove outer boots/gloves:

- If outer boots/gloves are disposable, deposit them in the appropriate plastic-lined container.

- If outer boots/gloves not disposable, store them in a clean, dry place.

Tank Change
Exchange air tank. Don new outer boots/gloves. Tape joints and return to exclusion zone.

LEVEL C ROUTINE DECONTAMINATION

Equipment Drop
Deposit equipment used on site (tools, sampling devices, monitoring equipment, radios, etc.) on plastic drop cloths. Decontaminate or dispose of items before removal from exclusion zone.

Outer Boot/Glove Wash and Rinse
Scrub outer boots/gloves and/or splash suit with decontamination solution then rinse with water.

Outer Boot/Glove Removal
Remove outer boots/gloves:

- If outer boots/gloves are disposable, deposit in them in the appropriate plastic-lined container.

- If outer boots/gloves are not disposable, store them in a clean, dry place.

Outer Garment Removal
Remove chemical-protective outer garments and deposit them in the appropriate container.

Respiratory Protection Removal
Remove hard hat and respirator and deposit them on a clean surface. Discard respirator cartridges in the appropriate container. Wash and rinse hard hat and respirator. Wipe off and store respirator in a clean, dry location.

Inner Glove Removal
Remove inner gloves and deposit them in the appropriate container for disposal.

Field Wash
Thoroughly wash hands and face with soap and water. Shower as soon as possible.

LEVEL C DECONTAMINATION FOR RESPIRATOR-CARTRIDGE EXCHANGE

Equipment Drop
Deposit equipment used on site (tools, sampling devices, monitoring equipment, radios, etc.) on plastic drop cloths. Decontaminate or dispose of items before removal from exclusion zone.

Outer Boot/Glove Wash and Rinse
Scrub outer boots/gloves and/or splash suit with decontamination solution then rinse with water.

Outer Boot/Glove Removal
Remove outer boots/gloves:

- If outer boots/gloves are disposable, deposit them in the appropriate plastic-lined container.
- If outer boots/gloves are not disposable, store them in a clean, dry place.

Respirator Cartridge Change
Exchange respirator cartridges. Don new outer boots/gloves. Tape joints and return to exclusion zone.

LEVEL D-MODIFIED ROUTINE DECONTAMINATION

Equipment Drop
Deposit equipment used on site (tools, sampling devices, monitoring equipment, radios, etc.) on plastic drop cloths. Decontaminate or dispose of items before removal from exclusion zone.

Outer Boot/Glove Wash and Rinse
(Optional, include if necessary for gross decontamination)
Scrub outer boots/gloves and/or splash suit with decontamination solution then rinse with water.

Outer Boot/Glove Removal
Remove outer boots/gloves:

- If outer boots/gloves are disposable, deposit them in the appropriate plastic-lined container.
- If outer boots/gloves are not disposable, store them in a clean, dry place.

Outer Garment Removal
Remove chemical protective outer garments and deposit them in an appropriate container. Remove hard hat and safety glasses. Decontaminate them as necessary and deposit on a clean surface.

Inner Glove Removal
Remove inner gloves and deposit them in the appropriate container for disposal.

Field Wash
Thoroughly wash hands and face with soap and water. Shower as soon as possible.

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FIELD EMERGENCY RESPONSE PROCEDURES

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FIELD EMERGENCY RESPONSE PROCEDURES

Based on the type of potential hazards that may be present, the Site Safety Officer (SSO) is to determine if a site specific emergency response plan is necessary prior to the beginning of work. If a site specific plan is necessary, it is to be attached to the Site Safety Plan (SSP).

FIRES AND EXPLOSIONS

Even a minor fire can become a serious problem, particularly when adjacent to flammable or combustible materials. The first few minutes after discovery of a fire are the most critical in preventing a larger emergency.

In case of a fire or explosion, immediately turn off burners and other heating devices and stop any work in progress. Give priority to assisting injured persons.

Small Fires
Take the following actions immediately:

- Alert other personnel in the vicinity and send someone for assistance
- If it is a small fire - one that can be extinguished within 30 seconds or with one fire extinguisher - attempt to extinguish the blaze if:
  - Conditions are safe
  - You have the proper type of fire extinguisher
  - You have been trained to use a fire extinguisher properly
  - You are not alone

The combination (ABC) extinguishers in the Montgomery Watson Emergency Kits can be used against the following classes of fires:

- Class A fires - ordinary combustible solids such as paper, wood, coal, rubber and textiles
- Class B fires - petroleum hydrocarbons (diesel fuel, motor oil and grease) and volatile flammable solvents
- Class C fires - electrical equipment

These extinguishers, however, are not effective against Class D fires which include combustible or reactive metals (such as sodium and potassium), metal hydrides or organometallics. Special Class D extinguishers are required.

Avoid entrapment by a fire; always fight from a position accessible to an exit.

If there is any chance that the fire can not be controlled by locally available personnel and equipment, the following action should then be taken:

- Activate the emergency alarm system (if available) and notify the local fire department.
- Confine the emergency to prevent further spread of the fire.
- Assist injured personnel and provide first aid or transportation to medical aid, if necessary.

Next notify client if the client is in close proximity to the fire. (If not, notify the fire department). Assess the need with the client to contact the fire department. If the fire department is contacted, be prepared to tell them:

- Who you are
- Your location
- Type of fire (i.e., electrical, chemical, combustible solids, vapor)
- If the fire is extinguished
- The need for medical assistance
- Other potential hazards in the area (i.e., proximity to bulk tanks, downed electrical lines, poor access)
- What you will be doing after you hang up the phone and where they can find you or reach you

Upon arrival of the local fire department, brief them of the incident. When given permission, contact the Project Manager (PM) or in the PM's absence, the Office Supervisor or Corporate Health and Safety Manager.

Large Fire or Explosion
If other people are in the area, immediately notify them and then call the local fire department. Be prepared to tell them:

- Who you are
- Your location
- Type of fire (i.e., electrical, chemical, combustible solids, vapor)
- If the fire is extinguished
- The need for medical assistance
- Other potential hazards in the area (i.e., proximity to bulk tanks, downed electrical lines, poor access)
- What you will be doing after you hang up the phone and where they can find you or reach you

Upon arrival of the fire department, turn over command to them and supply as much information as possible. When given permission, contact the PM or in the PM's absence, the Office Supervisor or Corporate Health and Safety Manager. Get a number where they can again be reached.

FLAMMABLE/COMBUSTIBLE LIQUID SPILLS

If a spill of a flammable or combustible liquid occurs, all possible sources of ignition should be extinguished or removed immediately.

Use Material Safety Data Sheets (MSDSs), analytical information from laboratory personnel, and any other available sources of information, together with your own expertise to determine if spill control and clean up can be safely accomplished with the personnel and materials on site.

The following general spill clean up procedures can be utilized, but more specific techniques might be required for certain chemicals.

- Vermiculite or other suitable absorbent may be used to solidify free liquids.
- Both spilled liquids and solids residues must be contained in drums.
- If a spill occurs on soil, it must be scraped and contained.

EVACUATION

Prior to beginning work, the SSO should brief all Montgomery Watson and subcontractor employees on what the evacuation signal should be. It may be nothing more than a verbal command or it may be some audible alarm such as a bell or horn. If working at a client's site, familiarize yourself with their warning system.

Prior to work, the SSO should determine a meeting place if evacuation is necessary. Preferably the meeting place should be upwind of the work activities and at a safe distance. All Montgomery Watson and subcontractor employees should be informed of the meeting location.

If evacuation is necessary, everyone should go directly to the meeting area. The SSO should ensure all personnel (Montgomery Watson and subcontractor) are accounted for. This will mean checking the sign-off documentation on the Site Safety Plan or on larger jobs the daily sign-in roster. The local on-scene commander should immediately be notified of any missing personnel as well as their last known whereabouts.

Site Evacuation
If an evacuation of the site is necessary, certain rules must be strictly followed:

- Employees in the vicinity should immediately shut down all equipment and disconnect electrical or flammable power sources to machinery.
- Immediately after personnel are alerted, they will evacuate the facility via the nearest escape route.
- All evacuated personnel will assemble at the predetermined meeting place.
- Employees should not wait for friends; the Site Safety Officer will ensure all personnel have evacuated before departing.
- Employees should move quickly and calmly without panic.
- Employees should not smoke.
- Once assembled, employees should remain calm and quiet while the Site Safety Officer takes roll call and assesses the situation. Each employee must report to the Site Safety Officer until everyone is accounted for and evacuation is complete.

Off-Site Evacuation

If an incident is large enough, off-site personnel may also need evacuation. If off-site evacuation is necessary, follow the appropriate local notification procedures, generally through the fire department. Montgomery Watson personnel should not attempt to evacuate off-site personnel but should leave that task to the local authorities. All Montgomery Watson employees should follow the evacuation directions given by the local authorities. The Site Safety Officer should offer to remain at the command post to supply information. If told to leave, the SSO should leave.

Local authorities will have present an on-scene commander. The on-scene commander will direct emergency operations and will have assistance from the local fire department, police department and emergency government.

After evacuating to a safe area, the PM should be contacted or in the PM's absence, the Office Supervisor or Corporate Health and Safety Manager.

DISCUSSION OF INCIDENT

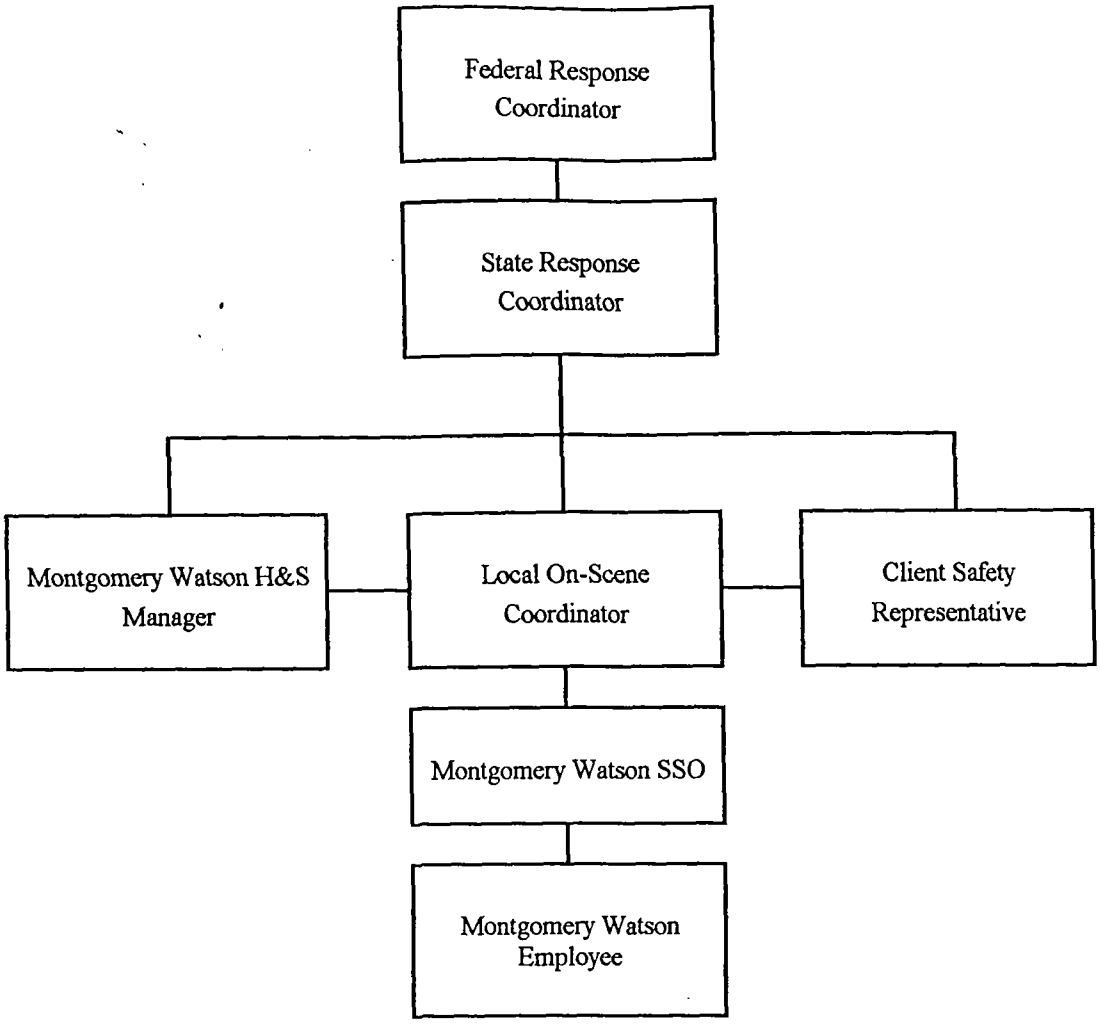
At no time should a Montgomery Watson employee discuss an emergency incident with members of the media. Politely refuse to discuss the situation and instead, direct all inquiries to the Corporate Health and Safety Manager. Provide the media people with the office phone number.

However, Montgomery Watson employees should always provide whatever useful information they can to response personnel. Stick to helpful facts and avoid placing blame or judgement. That will be sorted out later. Politely refuse to find fault or place blame.

At a safe place and at the appropriate time, write down all you remember of the incident. How did it happen? Who was doing what? What did I see? What did I hear? All these types of things may be important later when things are sorted out.

CHAIN-OF-COMMAND

The number of people involved in an incident will be directly related to the severity of the incident. In the event of an incident, the chain-of-command could be as extensive as:



Upon arrival of the local on-scene coordinator or client safety representative, the Montgomery Watson SSO should turn over command of the situation. The responsibility of the Montgomery Watson SSO is then to supply information and offer Montgomery Watson supplies and personnel if requested. It is likely the local on-scene coordinator or client safety representative will not request Montgomery Watson personnel but may request Montgomery Watson supplies (HNu, absorbent, drums). In a major incident, it is likely the Montgomery Watson Health and Safety Manager will arrive at the scene. At that time, all responsibilities of the SSO should be turned over to the Health and Safety Manager.

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ADDENDUM TO EMERGENCY RESPONSE PLAN

Emergency Response Planning

It is the objective of this SSP to minimize the potential for chemical, biological, and physical hazards, and operational incidents. As part of this program, emergency response planning provides procedures for responding to emergencies that may occur during the project. ***It is not the intention of this program to include professional emergency response activities as part of the field operations. Thus, all site personnel are instructed to assess emergencies in terms of whether the problem can be solved safely with the personnel and equipment at the site, or not. If it is determined that site personnel are able to contain the emergency safely, they should do so. If it is determined that the emergency is out of the realm of abilities for existing site personnel, evacuation and notification must take place immediately.*** This section provides general information for responding to emergency situations.

Emergency Medical Assistance Network: Emergency telephone numbers are provided in Section 7 and a map showing the locations of the hospitals or emergency clinics capable of providing emergency service for hazardous waste site workers is provided in Appendix C. Additionally, telephone numbers for the Poison Control Center, local Police and Sheriff's Department, local Fire Department (including their emergency rescue squad), Office of Emergency Services, Montgomery Watson management, and client contacts have been provided.

Standby Vehicles: Vehicles that can be used to transport injured personnel from work sites will be available during working hours.

Communication System: A telephone system will be available onsite for communication with offsite personnel. Onsite communication systems may include cellular phones, two-way radios or other suitable devices.

The Site Safety Officer (SSO) or Subcontractor's Designated SSO : The Montgomery Watson or subcontractor's OSO will be the lead person in emergency situations associated with onsite work.

First Aid and CPR: As many of the field team as is possible will be certified to render first aid and CPR prior to initiation of site activities. First aid supplies and potable water will be available at all sites. Additionally, portable emergency eye wash stations capable of supplying a continuous flow of water for 15-minutes, will be available at specific work locations where the possibility of contacting corrosive liquids or other eye splash hazards exist.

Project-specific Training: Prior to the start of work, all project personnel will receive training in the established emergency response procedures and associated equipment. A dry-run to each hospital will also be made, ensuring that each project team member knows the way to the nearest emergency facility.

Evacuation Routes: Evacuation routes will be clearly communicated to all project workers who will enter the decontamination or exclusion zone. This information will be posted at each work location and discussed during each tailgate safety meeting. A safe place of refuge will be determined on a site-by-site basis so that a headcount can be made following an emergency evacuation.

Emergency Alarm System: A compressed air horn will be carried into the exclusion zones for all operations to alert personnel of an emergency situation and pending evacuation.

Any unexpected vapor release, fire or explosion will cause all associated site work to cease and call for an immediate evacuation of the given worksite.

Emergency Decontamination: It is not anticipated that emergency decontamination of heavy equipment will be necessary. Emergency decontamination of site personnel may be necessary for medical reasons or in the event of major contamination by contact with contaminated material.

Emergency procedures will include:

- Assistance by on-site personnel for removal of contaminated protective clothing, when time permits.
- If the employee is injured and cannot be moved, attempts will be made to cut the clothing for removal.
- If the situation is life-threatening, decontamination or removal of protective clothing will be considered secondary to medical treatment. If appropriate, to minimize spread of contaminants, contaminated personnel will be wrapped in blankets and/or plastic sheeting (maintaining an open airway) during transport to the emergency treatment facility. Emergency personnel will be notified of the nature of the contaminated material and instructed on the importance of preventing skin contact.
- If the employee can walk or be moved without injury, all affected skin areas should be washed thoroughly with soapy water and rinsed.
- Disposal of equipment will be in appropriate collection containers.
- Non-disposable equipment will be placed and cleansed in the area provided for personnel to wash-down non-disposable equipment.

Project Health and Safety Reporting: All accidents, safety related incidents and safety-related near misses will be documented and reported to the Montgomery Watson Health and Safety Coordinator and company-specific health and safety contacts.

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First Aid

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FIRST AID

OPEN WOUNDS

Stop the bleeding by direct pressure, elevation, and if necessary, direct pressure on the supply artery. Do not attempt to cleanse severe wounds. Apply a sterile dry dressing to protect the wound from contamination. Provide shock care. Obtain medical attention.

MINOR BURNS

The object of first aid for burns is to relieve pain, prevent contamination, and prevent shock. First degree and second degree burns should be submerged in cold water until the pain subsides. Gently blot dry then apply a sterile dry dressing as a protective bandage. Do not break blisters, or remove any tissue. Do not use an antiseptic preparation, ointment or spray. Seek medical attention immediately if burns are severe.

EYE INJURIES

Foreign objects are often blown or rubbed into the eyes. Keep victim from rubbing eye. Wash hands before examining eye. Do not attempt to remove foreign objects by inserting toothpicks, or other instruments. If object is embedded in eye, seek medical attention immediately. If object is not embedded try to remove by teardrops, or flushing with water. If object is not easily removed, seek medical attention.

Contusions may be caused by direct blow or explosion. Stop hemorrhage by gently applying direct pressure, then protect eye from contamination with a dry sterile dressing. Seek medical attention immediately.

GENERAL SEQUENCE FOR TREATMENT OF EXPOSURES TO UNKNOWN CHEMICALS

1. Quickly protect yourself from exposure before attempting to rescue the victim.
2. Decontaminate the victim and terminate exposure.
3. Treat cessation of breathing first.
4. If the heart is not beating, perform cardiopulmonary resuscitation (CPR).
5. Treat eye injuries next.
6. Treat skin contact.
7. Treat shock.
8. Call for help.

PRELIMINARY ASSESSMENT

Make a quick assessment of the likely routes of exposure by examining the eyes, mouth, nose and skin of the victim for signs of the chemical itself or damage it has caused such as swelling, redness, bleeding, burns, discharge of fluid or mucous or pallor.

Drooling, difficult swallowing, a distended and painful or hard, rigid abdomen all indicate possible ingestion of a corrosive or caustic substance.

If respirations are rapid, shallow, noisy or labored, suspect inhalation.

If the face has been splashed with chemical, eye contact is likely.

POISONING BY INHALATION

Remove the victim from exposure while protecting yourself from exposure.

If breathing has stopped, administer artificial resuscitation using a disposable resuscitator and avoid mouth-to-mouth contact. **DO NOT** use mouth-to-mouth resuscitation if the nature of the chemical exposure is unknown.

Maintain an open airway.

Notify an emergency medical service of the nature of the accident and arrange for transport to a medical facility.

POISONING BY INGESTION

Remove the victim from exposure while protecting yourself from exposure.

Call a poison control center, emergency room or physician for advice.

Notify an emergency medical service of the nature of the accident and arrange for transport to a medical facility.

Consult the MSDS to determine whether to offer victim water to drink or to induce vomiting and by what means.

If the victim is conscious:

- Have the victim rinse out mouth with water.
- If there are no signs of burns, swallowing difficulty or abdominal problems and victim is conscious and if so advised by a physician or poison control center:
  - Induce vomiting by giving two teaspoons of Syrup of Ipecac. Follow with at least one cup of water. **DO NOT** use milk. If you do not have Syrup of Ipecac, induce vomiting by asking the victim to touch the back of the throat with a finger, spoon handle or blunt instrument.
  - Have the victim sit up or lean forward while vomiting.
  - Save any vomitus and give it to the emergency medical service personnel to take to the medical facility for analysis.
  - Give the victim one to two cups of water to drink after vomiting has ceased.
- Keep talking to the victim to prevent sleepiness.

If the victim is unconscious:

- Lay the victim on the victim's left side, bending the victim's right hip.
- Maintain an open airway.
- Arrange for transport to the nearest medical facility.
- Stand by to administer artificial resuscitation and CPR if needed. Be sure to wipe or rinse all traces of chemical from in and around the victim's mouth before giving artificial resuscitation. Always use disposable resuscitators supplied in the Montgomery Watson First Aid kits when performing CPR. **DO NOT** use mouth-to-mouth resuscitation if the nature of the chemical exposure is unknown.

- If breathing has stopped, administer artificial resuscitation using a disposable resuscitator and avoid mouth-to-mouth contact.

If the victim vomits, save the vomitus and send it to the medical facility for analysis.

If the victim shows signs of shock (a weak, rapid pulse; pale clammy skin; cold hands and feet), elevate the victim's feet eight to twelve inches and cover the victim with a blanket.

DO NOT give an unconscious person anything to drink.

DO NOT give someone who is convulsing anything to drink.

POISONING BY SKIN CONTACT

Remove the victim from the contaminated area, being careful to protect your lungs, skin and eyes.

Remove the victim's clothing, shoes and jewelry from the affected areas, cutting them off if necessary. Do this under a shower or while flushing with water.

Continue to flush with water until all trace of the chemical is gone and any slippery feeling has disappeared also. Rinse for at least 15 minutes.

Cover the victim with a blanket or dry clothing.

Notify a physician, emergency room or poison control center of the accident and obtain advice.

In case of inflammation, burns, blisters or pain:

- Loosely apply a dry sterile dressing, if available, or use a clean dry cloth.
- Notify an emergency medical service of the nature of the accident and arrange for transport to a medical facility.

- If the victim is in a state of shock:

  - Lay the victim down on the victim's side and cover the victim with a blanket.

  - Elevate the victim's feet eight to twelve inches.

  - Notify an emergency medical service of the nature of the accident and arrange for transport to a medical facility.

DO NOT break open blisters or remove skin. If clothing is stuck to the skin after flushing with water, do not remove it.

DO NOT rub or apply pressure to the affected area.

DO NOT apply any oily substance to the affected skin.

DO NOT use hot water.

POISONING BY EYE CONTACT

Remove the victim from the contaminated area, being careful to protect your lungs, skin and eyes.

Act quickly. Seconds count. Flush the victim's eye(s) with clean tepid water for at least 15 minutes. Have the victim lie or sit down and tilt head back. Hold eyelid(s) open and pour water slowly over the eyeball(s) starting at the inner corners by the nose and letting the water run out of the outer corners. The victim may be in great pain and want to keep eyes closed or rub them but you must rinse the chemical out of the eye(s) in order to prevent possible permanent damage.

Ask the victim to look up, down and side to side as you rinse.

Call an emergency medical service and arrange for transport to the nearest facility for examination and treatment as soon as possible. Even if there is no pain and vision is good, a physician should examine the eye(s) since delayed damage may occur.

If the eye(s) is(are) painful:

- Cover loosely with gauze or a clean, dry cloth
- Maintain verbal and physical contact with the victim

HYDROGEN CYANIDE EXPOSURE

Hydrogen cyanide is a Class A poison which can cause asphyxiation by ingestion, inhalation, or absorption of liquid or vapor through the skin (particularly eyes, mucous membranes, and feet). Hydrogen cyanide has a bitter almond odor and has a threshold limit value-ceiling-TLV-C of 4.7 ppm.

The SSO will notify the local medical facility if the potential for hydrogen cyanide exposure exists at the Site. This will allow emergency personnel to have the necessary equipment in the event of a cyanide exposure emergency.

Signs and Symptoms of Exposure

Inhalation

Very acute poisoning

- Victim cries out before losing consciousness
- Victim falls to the ground
- Wheezing
- Foaming at mouth
- Violent convulsions
- Almost immediate death

Acute poisoning

- Excitement phase
  - Headache
  - Breath smells of bitter almond
  - Dizziness
  - Nausea, occasionally vomiting
  - Rapid breathing
  - Anxiety and excitement
- Depression phase
  - Difficulty in breathing
  - Chest pain
  - Drowsiness
- Convulsion phase
  - Convulsions
  - Jaws clenched together
  - Foaming at mouth
  - Loss of consciousness

- Paralysis phase: If the subject survives, there is a risk of permanent nervous system damage.

  - Deep coma
  - Dilated pupils
  - Weak and irregular pulse
  - Breathing stops
  - Death

Slight poisoning

- Headache
- Dizziness
- Anxiety
- Difficulty in breathing

Ingestion
(See symptoms described under Inhalation - Acute to slight poisoning)
Burning tongue and mouth
Salivation
Nausea

Skin contact
The gaseous and liquid compounds are quickly absorbed by the skin and cause symptoms described under INHALATION, resulting in acute to slight poisoning. Depending on their nature, they can be very or only slightly irritating.

Splashing in eyes
Irritation and watering of eyes

When absorbed by mucous membranes of the eyes, these compounds can cause the same symptoms described in INHALATION, resulting in slight poisoning.

First Aid
Inhalation
Remove the victim from the contaminated area only after protecting yourself from exposure.

Have someone call the Emergency Medical Service and arrange for transport to a medical facility. Inform them of the nature of the exposure.

Remove contaminated clothing and equipment while wearing appropriate protective clothing.

If the victim has stopped breathing:

- Open airway, loosen collar and belt. Do not use direct mouth-to-mouth resuscitation for cyanide exposure. A bag-valve mask is required.
- Check the pulse.
- Continue your efforts until help arrives or the victim starts to breathe on their own.
- Keep the victim warm and quiet.

If the victim is unconscious but breathing:

- Lay the victim on their back. If the victim is vomiting, turn the head to the side.
- Clear the airway and loosen tight clothing.
- Keep victim warm and quiet.
- Do not leave the victim unattended.
- Never give an unconscious person anything to drink.

If the victim is conscious:

- Lay the victim down, cover the victim with a blanket and keep them quiet.
- Loosen tight clothing.

Ingestion

Start lifesaving treatment, call for help and, if possible, empty the stomach and prevent further injury caused by absorption. PROMPT TREATMENT IS LIFESAVING.

- Ask someone to call a poison control center, inform them of the chemical swallowed and follow their advice.
- Ask someone to call the Emergency Medical Service and arrange for transport to a medical facility.

If the victim is unconscious or unresponsive:

- Lay the victim on the left side and loosen the victim's collar and belt.
- Check the airway for obstruction.

If the victim stops breathing, administer artificial respiration using a bag-valve mask. Do not use direct mouth-to-mouth resuscitation.

If the victim is conscious and alert:

- Remove the victim from the contaminated area to a quiet, well ventilated area.
- Loosen tight clothing around the neck and waist.
- Have the victim rinse mouth several times with cold water and spit out.
- Give him 1 or 2 cups of water or milk to drink.
- Induce vomiting by touching the back of the throat with your finger, a spoon handle or a blunt object.
- Have the victim sit up and lean forward while vomiting.
- Save vomitus for analysis later. Avoid skin contact with it.
- Do not leave the victim alone.

DO NOT give an unconscious person or a person who is having a convulsion anything to drink. **DO NOT** give alcohol, drugs, or stimulants like tea or coffee. **DO NOT** continue to try to induce vomiting in someone who doesn't gag when you touch the back of his throat.

Skin contact

Remove the victim from the source of contamination and take them **IMMEDIATELY** to the nearest shower or source of clean water. Remove clothing, shoes, socks and jewelry from the affected areas as quickly as possible, cutting them off if necessary. Be careful not to get any of the chemical on your skin or clothing. Wash the affected area under tepid running water using a mild soap. Thoroughly rinse the affected area with tepid water. Dry the skin gently with a clean, soft towel. Notify a physician, emergency room, or poison control center and inform them of the nature of the substance and the accident. Arrange for transport to the nearest medical facility. Do not leave the victim alone. Watch for signs of systemic toxicity.

If the skin is inflamed or painful, put the painful part in cold water or apply cold wet dressings on the burned area.

Eye contact

Remove all the chemical from the eye(s) quickly. Remove the victim from the source of contamination and take them to the nearest eye wash, shower, or other source of clean water. Gently rinse the affected eye(s) with clean, lukewarm water for at least 15 minutes. Have the victim lie or sit down and tilt their head back. Hold the eyelid(s) open and pour water slowly over the eyeball(s) at the inner corners, letting the water run out the outer corners. Ask the victim to look up, down and side to side as you rinse in order to better reach all parts of the eye(s). Have the victim remove contact lenses if they are wearing them. Arrange for transport to the nearest medical facility for examination and treatment by a physician as soon as possible. Tell the Emergency Medical Service personnel the name of the chemical and the nature of the accident. Even if there is no pain and vision is good, a physician should still

examine the eye(s) since delayed damage may occur. If the victim cannot tolerate light, protect the eye(s) with a clean, loosely tied handkerchief or strip of clean, soft cloth or bandage. Be sure to maintain verbal communication and physical contact with the victim.

DO NOT let the victim rub eye(s). **DO NOT** let the victim keep eyes tightly shut. **DO NOT** introduce oil or ointment into the eye(s) without medical advice. **DO NOT** use hot water.

In all instances when performing First Aid procedures personnel should follow guidelines for Bloodborne Pathogens. Use the PPE - gloves, disposable mouth-to-mouth resuscitators, safety goggles and overgarments supplied in Montgomery Watson First Aid kits. Report all First Aid incidents to the Health and Safety Manager immediately.

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