TOWN OF SALINA LANDFILL

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

SITE I.D. NO. 734036

HEALTH AND SAFETY PLAN

PREPARED FOR:

TOWN OF SALINA
201 School Road
Liverpool, New York 13088

May 15, 1992
~~FEBRUARY 6, 1998~~

PREPARED BY:

CLOUGH, HARBOUR & ASSOCIATES LLP
Engineers, Surveyors, Planners & Landscape Architects
III Winners Circle
Albany, NY 12205

CHA Project No. 6967

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TOWN OF SALINA LANDFILL
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

The Health and Safety Plan contained herein was completed by Jholee Magee (qualifications attached) for the Town of Salina Landfill Remedial Investigation/Feasibility Study.

	Name	Signature	Date
Health and Safety Coordinator:	Jholee Magee	Jholee Magee	5/7/98
Project Manager:	Richard M. Loewenstein		5/7/98
QA/QC Manager:	Margaret M Rudzinski	Margaret M Rudzinski	5/1/98

JHOLEE N. MAGEE
ENVIRONMENTAL SCIENTIST, HEALTH & SAFETY COORDINATOR

Education

Columbia-Greene Community College/A.A.S. in Math/Science/1995
College of St. Rose/B.A. in Biology/1997

Experience

Ms. Magee joined CHA full time in June of 1997 as an Environmental Scientist and Health and Safety Coordinator in the firm's Chief Engineers Office. Ms. Magee has been responsible for providing support to all departments of the company, including our regional offices in safety issues, equipment and supplies, HAZWOPER training, and the company Hazard Communication, and Safety Manuals. These responsibilities include tracking the medical monitoring and training of all employees, keeping an inventory and maintaining the equipment and PPE, & updating both the Safety Manual and the Hazard Communication Program. Ms. Magee has set up several databases and spreadsheets for various purposes. She has set up and coordinated a system in which to track employee HAWOPER training, medical monitoring program, and other selective training.

- ☐ *Hazardous Waste Operations and Emergency Response.* HAZWOPER training conducted on an as-needed basis in accordance with 29 CFR 1910.120.
- ☐ *Confined Space Training.* Training conducted on an as-needed basis in accordance with 29 CFR 1910.146.
- ☐ *Health and Safety Plan Preparation.* Preparation of Facility Safety Manuals explaining the policies and procedures of the client.
- ☐ *Regulation Compliance.*
- ☐ *Right-to-Know Hazardous Communications.* Training conducted providing awareness chemicals, MSDS sheets, and labels.
- ☐ *Environmental Audits.*
- ☐ *Development of Site Safety Manuals.* Preparation of Site specific Safety Manuals for field operations ranging from bridge inspection projects to landfill reclamations and chemical sewer inspections.

Professional Activities and Registration

8-hour Lead Safety Training (OSHA)
10-hour OSHA General Industry Safety and Health Training
10-hour OSHA Construction Safety and Health Training
40-hour HAZWOFER Training
4-hour Confined Space Entry Training
On-Track Safety Training CT Department of Transportation
Troxeler Nuclear Guage Operator Training
Dale Carnegie Graduate
Member of AIHA

DISCLAIMER

This Site Health & Safety Plan has been written for the use of Clough, Harbour & Associates LLP (CHA) and their employees. Properly trained and experienced CHA subcontractors may also use it as a guideline document. However, CHA does not guarantee the health and safety of any person entering the site.

Due to the potentially hazardous nature of the project and the activity occurring thereon, it is not possible to discover, evaluate and provide protection for all possible hazards, which may be encountered. Strict adherence to the health and safety guidelines set forth herein will reduce, but not eliminate, the potential for injury at the project. The health and safety guidelines in this plan were prepared specifically for this project and should not be used on any other project without prior research by trained health and safety specialists.

CHA claims no responsibility for the use of this Plan by others. The Plan is written for the specific site conditions, purpose, dates, and personnel specified and must be amended if these conditions change.

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1.0 INTRODUCTION

The following Health and Safety Plan has been created for the protection of CHA staff on the Town of Salina Municipal Landfill, located in the Town of Salina, Onondoga County, New York. This project's various assignments require CHA employees to perform tasks where personal safety could be compromised due to chemical, physical, and biological hazards. While conducting fieldwork, CHA employees may be exposed to chemical including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals. CHA employees may be exposed to physical hazards, including but not limited to heavy machinery, excavations, and trip/fall hazards. CHA employees may be exposed to biological hazards, including but not limited to insects, poison ivy/oak/sumac, and animals.

2.0 KEY PERSONNEL

2.1 OFF-SITE PERSONNEL

Title: Senior Level Management
Description: Responsible for defining project objectives, allocating resources, determining the chain of command, and evaluating program outcome.
Contact: Richard Loewenstein, P.E. @ (518) 453-2893

Title: Project Team Leader
Description: Reports to upper level management, has authority to direct response operations, assumes total control over site activities.
Contact: Christopher Burns, Ph.D., P.G. @ (315) 471-3920

Title: Scientific Advisor
Description: Guides the Project Team Leader in scientific matters.
Contact: Margaret Rudzinski, @ (518) 453 - 2830, Jholee Magee, @ (518) 453 - 4510

2.2 ON-SITE PERSONNEL

Title: Site Health & Safety Officer
Description: Advises the field team on all aspects of health and safety issues, recommends stopping work if any operation threatens worker or public health and safety.
Contact: Steve Pidgeon, @ (518)453 - 4553 or alternate

Title: Field Team Leader
Description: Responsible for field team operations.
Contact: Steve Pidgeon, @ (518) 453 - 4553, or alternate

Title: Work Party
Description: Performs field operations
Contact: CHA personnel to be identified

2.3 AS-NEEDED PERSONNEL

Title: Fire Department
Description: Responds to fires and performs rescues
Contact: *911

Title: Hazardous Chemical Cleanup Contractor
Description: Contaminant control methods and emergency response.
Contact: *911

3.0 SITE ENTRY

3.1 OBJECTIVES

The objectives of the site entry are to complete a remedial investigation/feasibility study. The site characterization requires entry to the site by CHA personnel. The tasks that will be completed include a site survey, ecological investigation, waste area investigation, groundwater investigation, surface water/sediment investigation, surface soil investigation, and multi-media sampling.

3.2 SAFETY MEETINGS

To ensure that the Health and Safety Plan is being followed, the Site Safety Officer (SSO) shall conduct a safety meeting prior to entry to the site or the initiation of any site activity, if any conditions change, and before each work day.

3.3 SAFETY TRAINING

The SSO will confirm that every person assigned to a task has had adequate training for that task and that the training is up-to-date by checking with the CHA Safety Coordinator. On-site CHA staff working on this project shall have a minimum of 24 hours or 40 hours of HAZWOPER training and current 8-hour HAZWOPER refresher training, and crew leader will have 8-hr supervisory training.

All training will have been conducted and certified in accordance with OSHA regulations as outlined in 29 CFR 1910.120.

3.4 MEDICAL SURVEILLANCE

All on-site CHA personnel will have had a medical surveillance physical consistent with OSHA regulations in 29 CFR 1910.120 and performed by a qualified occupational health physician. The SSO shall confirm prior to initiation of work on this site that every person assigned to a task has had an annual physical, has passed the medical examination, has been determined medically fit by the occupational health physician for this type of work, has had a pulmonary function and respirator fit test, and has passed them.

3.5 SITE MAPPING

Site mapping has been included as Appendix I.

4.0 SITE CHARACTERIZATION

4.1 SITE DESCRIPTION

The site is a municipal landfill that was used for the disposal of domestic, commercial, and industrial waste from prior to 1956 until 1974. The landfill encompasses about 50 acres off of New York State Route 11 (Wolf Street). The landfill is bordered by Ley Creek and industrial properties to the south, New York State Thruway to the North, Wolf Street and commercial properties to the east, and the Onondoga Transfer and sewage pumping station to the west. The site is situated in a flood prone area adjacent to Ley Creek, and was a wetland prior to becoming a landfill. The nearest wetlands are about 2,000 feet to the North and also some located to the east and southwest of the site.

Six hundred forty tons of paint sludge and 22 tons of waste paint thinner were documented as being disposed of at the Salina Landfill site by GM Fisher Guide Division from 1962 to 1973 (General Motors 1985). PCB contaminated wastes in the form of oil-saturated sorbents used in floor cleanups were disposed of by GM at the landfill, although the waste was not inventoried or tracked and therefore, the amount is unknown. Other industrial wastes such as buffing sludge and fly ash were also dumped at the landfill by GM. Drummed wastes from Carrier Corporation's Thompson Road Plant in Syracuse were disposed of at the Salina Landfill from 1974 to 1979. The amount of waste is unknown, and the contents of the drums may have included 2-butanone, toluene, xylene, and solder flux, among other substances.

The landfill closed in 1975, but the site was not covered and graded until 1982. Hazardous wastes associated with documented disposal have been documented at the site in the form of PCBs at levels greater than 50 PPM.

4.2 NEIGHBORING PROPERTIES

The site is located in an industrial area with other waste disposal areas in the vicinity. Ley Creek and industrial properties to the south, New York State Thruway to the North, Wolf Street and commercial properties to the east border the landfill, and the Onondoga Transfer and sewage pumping station to the west.

4.3 SITE TOPOGRAPHY

The topography of the site is flat and the elevation is about 390 feet above sea level.

4.4 METEOROLOGIC DATA

The fieldwork for the first phase of the project is expected to be conducted in the summer months of June and July. The weather and temperature for that time of year is expected to be hot, hazy, and humid. The fieldwork for the second phase of the project is expected to be conducted during the month of December. The weather and temperature for that time of year is expected to be cold with the possibility of precipitation. Prior to each day's activities, the daily forecast should be monitored for indications of adverse work conditions. If poor weather hinders the continuation of the day's activities the Team Leader may stop work for the day.

5.0 HAZARD EVALUATION

5.1 CHEMICAL HAZARDS

Site personnel may be exposed to the following chemical hazards.

Chemical	Target Organ
Acetone	Eyes, skin, respiratory system, CNS
Vinyl Chloride	Liver, CNS, blood, respiratory system, lymphatic system
1,2-dichloroethane	Eyes, skin, CNS, kidneys, liver, CVS
1,2-dichloroethene	
1,2-dichlorobenzene	Eyes, skin, respiratory system, liver, kidneys
1,1,1-trichloroethane	Eyes, skin, CNS, CVS, liver
Toluene	Eyes, skin, respiratory system, CNS, liver, kidneys
1,4-dichlorobenzene	Liver, respiratory system, eyes, kidneys, skin
Antimony	Eyes, skin, respiratory system, CVS
Aluminum	Eyes, skin, respiratory system
Copper	Eyes, skin, respiratory system, liver, kidneys
Iron	Respiratory system
Lead	Eyes, GI tract, CNS, kidneys, blood, gingival tissue
Manganese	Respiratory system, CNS, blood, kidneys
Mercury	Eyes, skin, respiratory system, CNS, kidneys
Zinc	Respiratory system
Arsenic	Liver kidneys, skin, lungs, lymphatic system
Cadmium	Respiratory system, kidneys, prostate, blood
Chromium	Eyes, skin, respiratory system
Cobalt	Skin, respiratory system
Nickel	Nasal cavities, skin, eyes
Vanadium	Eyes, skin, respiratory system
Cyanide	Brain, heart, lungs, skin, blood
PCB (Aroclor 1254)	Skin, eyes, liver, reproductive system

Beryllium	Eyes, skin, respiratory system
Selenium	Eyes, skin, respiratory system, liver, kidneys, blood, spleen
Thallium	Eyes, respiratory system, CNS, liver, kidneys, GI tract, body hair
Silver	Nasal septum, skin, eyes
Carbon disulfide	CNS, PNS, CVS, eyes, kidneys, liver, skin, reproductive system
Chlorobenzene	Eyes, skin, respiratory system, CNS, liver
Pentachlorophenol	Eyes, skin, respiratory system, CVS, liver, kidneys, CNS
PCB (Aroclor 1242)	Skin, eyes, liver, reproductive system
Dieldrin	CNS, liver, kidneys, skin
Benzene	Eyes, skin, respiratory system, blood, CNS, bone marrow
Barium	Skin, eyes, mucous membranes, lung, heart
Calcium	Eyes, skin, respiratory system
Iron	Eyes, respiratory tract, liver, and pancreas
Magnesium	Respiratory tract, skin, eyes, digestive tract
Potassium	Eyes, skin, respiratory system
Sodium	Eyes, skin, digestive and respiratory tract
Zinc	Respiratory system
4,4-DDD	Eyes, skin, respiratory tract, CNS, liver
4,4-DDT	CNS, liver, skin, PNS

5.2 EXPOSURE LIMITS

OSHA PELs and ACGIH TLVs for the above chemical hazards are listed below.

Chemical	PEL/TWA
Acetone	1000 ppm
Vinyl Chloride	1ppm
1,2-dichloroethene	
1,2-dichloroethane	100ppm

Total Xylenes	100 ppm
1,1,1-trichloroethane	350 ppm
Toluene	200 ppm
1,4-dichlorobenzene	75 ppm
Carbon disulfide	20 ppm
Chlorobenzene	75 ppm
Aluminum	ND
Barium	0.09 ppm
Calcium	----
Copper	0.039 ppm
Lead	0.0059 ppm
Magnesium	5.02 ppm
Manganese	2.225 ppm
Mercury	0.006 ppm
Zinc	ND
Arsenic	0.0033 ppm
Cadmium	0.00109 ppm
Chromium	0.47 ppm
Cobalt	0.04 ppm
Nickel	0.42 ppm
Silver	0.023 ppm
Sodium	2.13 ppm
Vanadium	0.0067 ppm
Cyanide	4.69 ppm
Antimony	0.1 ppm
Beryllium	0.005 ppm
Iron	1.53 ppm
Potassium	----
Selenium	0.06 ppm
Thallium	0.012 ppm
PCB (Aroclor 1254)	0.038 ppm

PCB (Aroclor 1242)	0.095 ppm
Dieldrin	0.25 ppm
4,4-DDT	0.069 ppm
Benzene	1 ppm
1,2-dichlorobenzene	50 ppm
Pentachlorophenol	0.046 ppm

5.3 DISPERSION PATHWAYS

The potential exposure mechanism that can transport particulates and VOC's from the areas of the inspection and monitoring to other areas of the site as well as beyond the boundaries of the site are:

- Contaminated dust projected by air currents
- Failure to adhere to proper decontamination procedures
- Contact with the groundwater

5.4 PHYSICAL HAZARDS

Physical hazards such as the following may be encountered on site:

- Slip/trip/fall hazards - protruding drums, vegetation, rocks, ice, etc.
- excavations - test pits
- Heavy machinery and vehicles - backhoe, trucks, drill rig, etc.
- heat stress/cold stress

5.5 BIOLOGICAL HAZARDS

Biological hazards such as the following may be encountered on site:

- poisonous plants – poison ivy, poison oak, poison sumac
- animals – deer ticks, rabid animals, snakes, stray animals

6.0 AIR MONITORING AND ACTION LEVELS

6.1 AIR MONITORING

The following environmental monitoring instruments shall be used on site at the specified intervals.

Photoionization Detector (PID)

A PID with an 11.7 eV lamp shall be used continuously during excavation of the test pits and installation of the borings to monitor for volatile organic compounds. The PID shall be calibrated daily following manufacturers recommendations. Calibration data shall be recorded in daily logs by the SSO.

Dust

Dust levels shall be visibly monitored. If it appears dust levels are increasing, a particulate meter shall be utilized following the manufacturer's recommendations.

Temperature

Ambient temperature should be monitored throughout the work day for potential cold stress conditions. Relevant monitoring information is included as Appendix II.

Quad Alarm Gas Monitor

Oxygen, Carbon monoxide, Hydrogen sulfide, and combustible gas levels shall be monitored continuously upon entering any excavation. Combustible gas levels will be monitored periodically using the Gas Monitor. The Gas Monitor shall be calibrated daily following manufacturers recommendations. Calibration data shall be recorded in daily logs by the SSO.

Radiation Survey Meter

Radiation levels shall be monitored continuously by use of a radiation/ionization detector.

6.2 ACTION LEVELS

Should action levels be reached, work operations shall cease until further evaluation is performed and safe levels are prevalent. If through engineering controls and monitoring, safe levels (below action levels) cannot be achieved, an upgrade in personal protection equipment shall be mandated by the SSO, or operations shall cease in that portion of the site. The action levels are as follows:

- Volatile organic compounds (PID monitor) = consistent readings of >5ppm

- Particulates (Particulate meter) = respirable 5mg/m^3, total 15 mg/m^3
- Atmospheric gases (Quad Alarm)
    Oxygen = 19.5%-23.5%, above or below requires an SCBA
    Carbon Monoxide = >35ppm, requires an SCBA
    Hydrogen Sulfide = >10ppm, requires an SCBA
    Combustible gases = >10% LEL, requires an SCBA
- Lead = 30 ug/m^3 respirable, 50 ug/m^3 permissible exposure limit
- Temperature = body core temperature of < 36°C for cold stress
- Radiation Survey = 1 Mr./hr.

6.3 ENVIRONMENTAL SAMPLING

Test pits will be excavated to identify the type of waste on site. A soil gas survey will be conducted to detect the presence of methane gas in the landfill.

Two rounds of multimedia sampling will be conducted. The sampling will include collection and analysis of groundwater samples, surface water and sediment samples, and surface soil samples. These samples will be analyzed for the full Target Compound List of chemical parameters with the exception of the seven temporary wells that are being installed along the southern edge of the landfill. The temporary wells will be sampled for leachate indicator parameters only. Groundwater samples will also be analyzed for both total and dissolved metals, and various leachate indicator parameters.

6.4 COMMUNITY AIR MONITORING

Real-time air monitoring for volatile organic compound and particulate levels shall be monitored at the perimeter of the Exclusion Zone.

Volatile organic compounds shall be monitored at the downwind perimeter of the Exclusion Zone daily at two-hour intervals. If total organic vapor levels exceed 5 ppm above background, intrusive activities shall be halted and monitoring continued under the provisions of the Vapor Emission Response Plan. All readings shall be recorded and available for New York State Department of Environmental Conservation (NYSDEC) and New York State Department of Health (NYSDOH) personnel to review.

Particulates shall be continuously monitored downwind of the Exclusion Zone with a portable particulate monitor having an alarm set at 150 ug/m^3. If downwind particulate levels, integrated over a period of 15 minutes, exceed 150 ug/m^3, particulate levels upwind of the Exclusion Zone shall be measured. If the downwind particulate level is more than 100 ug/m^3 greater than the upwind particulate level then all intrusive activities shall be stopped and corrective action taken. All readings shall be recorded and available for NYSDEC and NYSDOH personnel to review.

6.4.1 Vapor Emission Response Plan

If the ambient air concentration of the organic vapors exceeds 5 ppm above background at the perimeter of the Exclusion Zone, intrusive activities shall be halted and monitoring continued. If the organic vapor level decreases below 4 ppm above background, intrusive activities can resume but more frequent intervals of monitoring, as directed by the Site Health and Safety Officer, must be conducted. If the organic vapor levels are greater than 5 ppm over background but less than 25 ppm over background at the perimeter of the Exclusion Zone, intrusive activities can resume provided the following occur:

- The organic vapor level in the northeast portion of the site is below 10 ppm over background.
- The organic vapor level 200 feet downwind of the active work area is below 5 ppm over background, and
- More frequent intervals of monitoring, as directed by the Site Health and Safety Officer, are conducted.

If the organic vapor level is above 25 ppm at the perimeter of the Exclusion Zone, work activities shall be shut down. When work shutdown occurs, downwind air monitoring as directed by the Site Health and Safety Officer shall be implemented to ensure that vapor emission does not impact the nearest residential or commercial structure at levels exceeding those specified in the Major Vapor Emission Response Plan.

6.4.2 Major Vapor Emission

If any organic vapor levels greater than 5 ppm over background are identified 200 feet downwind from the active work area or at the site perimeter, all work activities shall be halted.

If, following the cessation of the work activities, or as the result of an emergency, organic vapor levels persist above 5 ppm above background 200 feet downwind from the Exclusion Zone, then the air quality shall be monitored within 20 feet of the perimeter of the nearest residential or commercial structure (20-Foot zone).

If either of the following criteria is exceeded in the 20-Foot Zone, then the Major Vapor Emission Response Plan shall automatically be implemented:

- Organic vapor levels approaching 5 ppm above background for a period of more than 30 minutes.
- Organic vapor levels greater than 10 ppm above background for any time period.

6.4.3 Major Vapor Emission Response Plan

Upon activation the following activities shall be undertaken:

- Local police and authorities shall immediately be contacted by the Site Health and Safety Officer and advised of the situation.
- Air Monitoring shall be conducted at 30-minute intervals within the 20-Foot Zone. If two successive readings below action levels are measured, air monitoring may be halted or modified by the Site Health and Safety Officer.

7.0 SITE CONTROL MEASURES

All site work zones (Figure 7-1) will be clearly marked and discussed with the field team leader. Site work zones shall consist of the exclusion, support, and contamination reduction zones.

The **exclusion zone** is the zone which contamination does or is most likely to occur. For this particular project the exclusion zone shall be established around each work location (e.g., test pit excavations, test borings) plus a radius of 5 feet, prior to work commencing at each location. An access point shall be established at the periphery of the zone to regulate the flow of personnel and equipment into and out of the zone. While in the exclusion zone all personnel must wear the specified personal protective equipment (PPE). Continuous monitoring must also be performed within the exclusion zone with the specified monitoring equipment, and within the specified guidelines.

The **contamination reduction zone** will be located at the periphery of the exclusion zone. This area will contain the decontamination station. All outer clothing that is worn within the exclusion zone must be removed and disposed of before leaving the contamination reduction zone.

The **support zone** will be located at the periphery of the contamination reduction zone. This area will be used for operational direction and support facilities, emergency response, supplies/equipment, and worker rest areas are to be established. Refer to the map in Appendix III for the site work zone layout.

7.1 COMMUNICATION

The method of communication shall be by two-way radios, and verbal signals or hand signals. Communication procedures will be reviewed at the Safety Meeting before entering the exclusion zone. A sign-in logbook will be on site in the trailer to account for all personnel on site.

7.2 SITE SECURITY MEASURES

All zones shall be clearly marked (temporary fencing) and reviewed at the Safety Meeting. All personnel shall report to the field team leader upon entering; therefore, everyone will be accounted for.

8.0 HAZARD COMMUNICATION

In compliance with 29 CFR 1910.1200, any hazardous materials brought on site by any personnel (CHA or contractors) shall be accompanied with the material's MSDS. The SSO shall be responsible for maintaining the MSDSs on site, reviewing them for hazards that working personnel may be exposed to, and evaluating their use on site with respect to compatibility with other materials including personal protective equipment, and their hazards. Should the SSO deem the material too hazardous for use on site, the party responsible for bringing the material on site shall remove it from the site.

9.0 CONFINED SPACE

A confined space entry is not anticipated during this project; however, test pits and excavations are considered confined spaces. In the event that a confined space entry is necessary then all confined space entry procedures, techniques, and equipment shall be consistent with OSHA regulations in 29 CFR 1910.146.

10.0 PERSONAL PROTECTIVE EQUIPMENT

Based on evaluation of the potential hazards for the site, the initial levels of PPE have been designated as **Level C**. Level C consists of, at a minimum, hard hat, safety glasses, work boots, long pants, long sleeved shirt, disposable or protective coveralls, inner gloves, outer gloves, disposable overboots or hazmat boots, and a full-face or half-mask negative pressure respirator with the appropriate cartridges. An orange hardhat and a reflective vest are required while heavy machinery and vehicles are on the site. Hearing protection is required and shall be used at the discretion of the SSO. No changes to the specified levels of PPE shall be made without the approval of the SSO and the Project Team Leader. If action levels are reached, work shall cease and the SSO and his advisors shall perform further evaluations. If necessary, an upgrade in PPE shall be mandated. A PPE guide has been included as Appendix IV.

Organic vapor/acid gas/HEPA cartridges are the appropriate canister for use with the involved substances. All respirators used shall be approved by NIOSH and/or MSHA and their use shall be consistent with OSHA regulations in 29 CFR 1910.134. All on-site personnel wearing a respirator shall have respirator clearance from a qualified occupational health physician. In addition, the respirator wearers on site shall perform qualitative fit tests to ensure proper fit of the face seal of the respirator. Inspection logs shall be completed, signed and kept with the Health and Safety Plan. Filter cartridges used shall be of the same manufacturer as the respirator and shall be changed on a daily basis at a minimum and/or if breathing becomes difficult.

Air purifying respirators shall not be used if any of the following conditions exist:

- Oxygen deficiency
- IDLH concentrations of specific substances
- Entry into an unventilated or confined area which has not been characterized
- Presence or potential presence of unidentified contaminants
- Contaminant concentrations are unknown or exceed designated maximum use specifications
- Identified gases or vapors have inadequate warning properties
- High relative humidity, may reduce protection offered by sorbent

While digging test pits or drilling test borings, excavations and boreholes shall be clearly marked and all site personnel made aware of their location. All site personnel shall wear a reflective vest as well as orange hardhats in order for machine operators to visually be aware of their location on site.

11.0 DECONTAMINATION

11.1 PPE

A dry decontamination procedure for personal protective equipment will be used during this project. All disposable PPE (excludes hardhat, safety glasses, reflective vest, and respirator) will be removed and placed in heavy plastic bags. The hardhat, safety glasses, and vest may be kept within the contamination reduction zone and disposed of at the end of the project. The respirators will be cleaned after each use with non-alcoholic respirator wipes. For additional information see Appendix V for decontamination procedures.

11.2 HEAVY EQUIPMENT

All equipment that comes into contact with potentially contaminated materials will be decontaminated prior to being re-used, or discarded and replaced. Equipment decontamination will be performed on plastic sheeting in the contamination reduction zone using an Alconox and water mixture. Contaminated water will be collected in 55-gallon DOT-approved drums and disposed of or treated on site. Discarded solids and PPE will be placed in 55-gallon drums, along with soiled plastic sheeting, and properly disposed of.

Decontamination procedures for all equipment used to collect samples is:

- i) wash and scrub with tap water and low phosphate detergent
- ii) tap water rinse;
- iii) methanol rinse;
- iv) thorough rinse with deionized demonstrated analyte-free water; and
- v) air dry.

All cleaned equipment will be placed on a substrate such as polyethylene sheeting or aluminum foil in order to avoid contacting a contaminated surface prior to use.

12.0 EMERGENCY PROCEDURES

The following emergency procedures will be used by on-site personnel. The SSO shall be notified of any on-site emergencies and be responsible for ensuring that the appropriate measures are followed. Non-emergencies will be treated on site and documented and then directed to seek further medical attention. All occupational injuries and illnesses will be reported, recorded, and investigated.

At least one person on site at all times must have a minimum of 8 hrs first aid training and CPR training. Each crew will be equipped with an air horn and walkie-talkie for communication purposes, if appropriate. Other emergency equipment, including a first aid kit, fire extinguisher, and flashlight will be on site at all times. In the case of a medical emergency, indicated by one long blast on an air horn, the crews will then communicate by walkie-talkie to determine the nature of the emergency and the location. After the SSO determines whether there is an actual emergency, he/she will instruct someone to call for an ambulance. The on-site trailer is equipped with a phone to be used to place such a call.

If an emergency evacuation of the site must take place, signaled by 2 short blasts on the air horn, all personnel on site will immediately stop work, shut off all equipment, and assemble at the site trailer (see map in Appendix III). The SSO will check the sign-in/sign-out logbook to make sure everyone is at the site trailer. After assembly of all personnel, the site will be evacuated using vehicles parked in the support zone. All vehicles will be parked facing out to enable a quick exit from the site. If time permits, as determined by the SSO, emergency decontamination will take place. This will consist of a wash and rinse of overboots, removal of disposable clothing, and washing of hands and face. After exiting the site, all personnel will reassemble at the end of. If the head count reveals someone is still on site, the SSO and his/her assistant will look for the person(s), using appropriate personal protection, i.e., Level B if the IDLH is exceeded.

12.1 PERSONNEL INJURY

Upon notification of personnel injury the nature of the injury will be assessed, the appropriate first aid shall be initiated and, if necessary, contact shall be made for an ambulance and with the designated medical facility. If the injury increases the risk to others, activities on site will stop until the added risk is removed or minimized.

12.2 FIRE/EXPLOSION

Upon notification of fire or explosion, the designated emergency signal (2 short blasts) shall be sounded and all site personnel shall assemble at a safe distance upwind of the involved area. The SSO shall alert the appropriate fire department.

12.3 PPE FAILURE

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

12.4 CHEMICAL EXPOSURE

If any site worker experiences adverse effects due to chemical exposure, the appropriate first aid procedures shall be followed according to the Material Safety Data Sheets for that chemical (Appendix VI). The person shall at a minimum be moved to fresh air. In the case of accidental skin contact with contaminated materials, the area will be washed thoroughly for at least 5 minutes. If the eye is affected, it will be rinsed for 15 minutes, making sure the chemical does not wash into the other eye. In case of accidental ingestion of contaminated material, the poison control center will be called before giving anything to the victim. If the victim needs to receive additional medical care, decontamination will be done if possible.

13.0 EMERGENCY MEDICAL CARE

These directions and numbers will be prominently posted in the site trailer.

13.1 NEAREST HOSPITAL

The nearest hospital to the site is St. Joseph's Hospital.

Leave the Site from Wolf Road

Travel southwest on Wolf Road

Turn Left onto North Salina Street

Continue to Prospect Street

St. Joseph's Hospital is on the Right.

A map to the hospital is found in Appendix VII.

13.2 EMERGENCY NOTIFICATION NUMBERS

Fire Dept.: *911

Police Dept.: *911

Dept of Emergency Services: *911

Emergency Room – (315) 448 - 5111

Hazardous Materials Response Team: *911

Poison Control: 1-800-336-6997

CHA (315) 471-3920 contact: Christopher Burns

13.3 ON-SITE FIRST AID

A first aid kit shall be maintained and stored within the Contamination Reduction Zone.

14.0 STANDARD OPERATING PROCEDURES

The following standard operating procedures shall be implemented during this project:

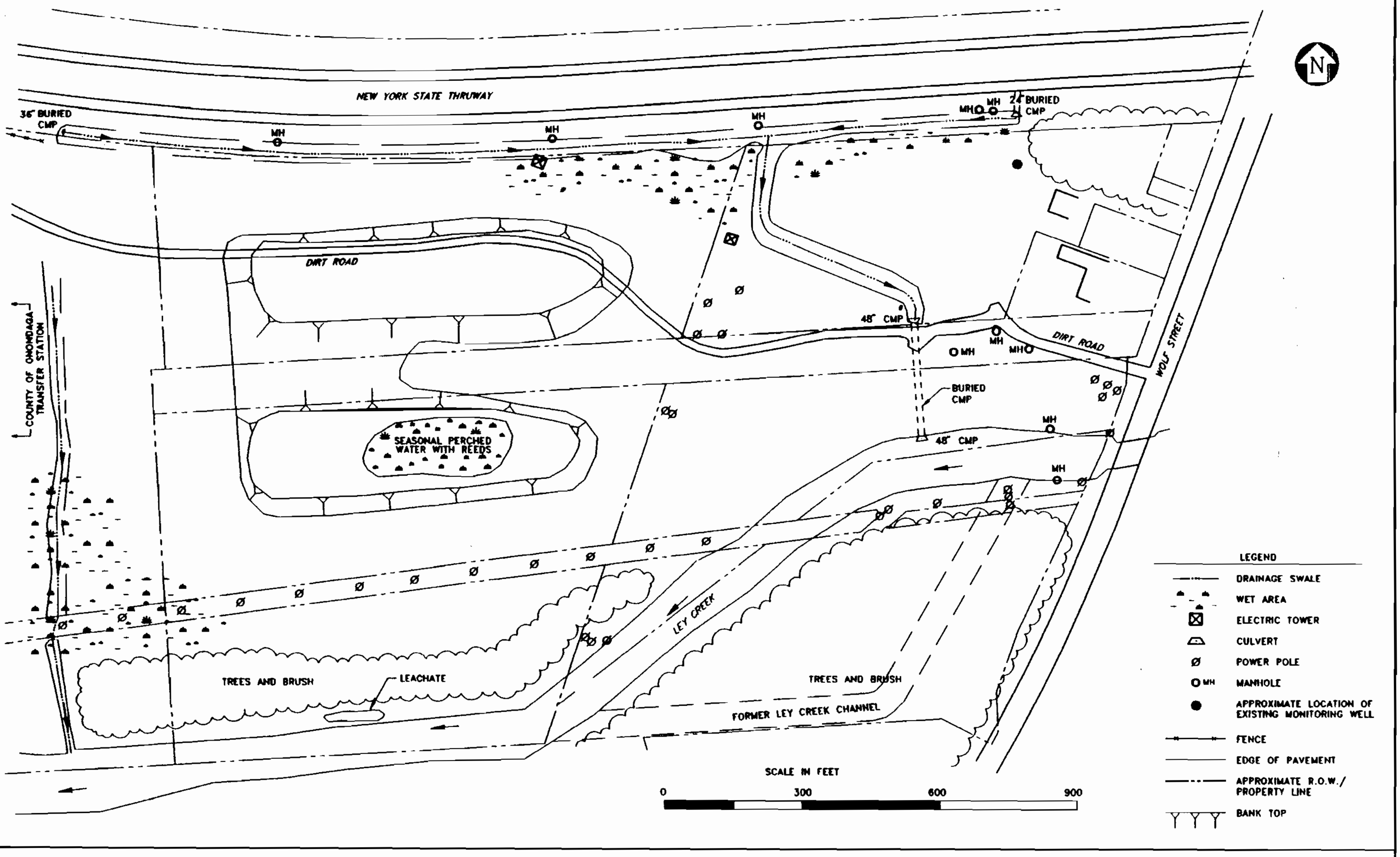
- Minimize contact with hazardous substances
- Use remote sampling, handling, and container-opening techniques whenever possible
- Protect monitoring and sampling instruments by bagging
- Wear disposable outer garments and use disposable equipment where appropriate
- Use proper dressing procedures before entering the Exclusion Zone and use all fasteners (zippers, snaps, buttons, etc.)
- All personal protective equipment and skin surfaces should be checked for cuts and/or punctures
- Do not eat, smoke, or drink on site. Avoid any practice that may increase the probability of hand-to-mouth transfer and ingestion of material. Avoid any application of cosmetics.
- Avoid brushy areas to minimize allergic reactions to poison ivy, deer ticks, etc.
- Prescribed drugs should not be taken by personnel where the potential for absorption, inhalation, or ingestion of toxic substances exists unless specifically approved by a qualified person. Alcoholic beverages intake should be avoided.
- All personnel must be familiar with the Client's operating safety procedures.
- The buddy system must always be used and enforced.
- Personnel entering the Contamination Reduction Zone and/or the Exclusion Zone must check in and out at the Access Control Points.
- All subcontractors shall abide by this Health & Safety Plan or provide one that is equivalent, at a minimum, to the conditions specified in this Health & Safety Plan.
- No workers with beards or heavy side burns are allowed to wear respirators.
- Use of contact lenses on site is prohibited unless safety glasses are worn at all times.

15.0 CERTIFICATION

All site personnel covered by this HASP have read the HASP and are familiar with its contents and provisions.

Name	Title	Date

APPENDIX I



SITE PLAN

FIGURE NO. 2

SCALE: 1" = 300'±

PROJECT NO. 6967

DATE: FEBRUARY 1998

CHA
CLOUGH, HARBOUR & ASSOCIATES
ENGINEERS, SURVEYORS, PLANNERS & LANDSCAPE ARCHITECTS
109 SOUTH WARREN STREET SYRACUSE, NEW YORK, 13202

TOWN OF SALINA LANDFILL
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SALINA, NEW YORK

FILENAME: I:\6967\FIG2

APPENDIX II

HEAT STRESS MONITORING

MONITORING

Monitoring frequencies should increase as the ambient temperature increases or as slow recovery rates are observed. Heat stress monitoring should be performed by a person with a current first aid certification who is trained to recognize heat stress symptoms. For monitoring the body's recuperative abilities to excess heat, one or more of the following techniques will be used. Other methods for determining heat stress monitoirng, such as wet bulb globe temperature (WBGT) index from American Conference of Governmental Industrial Hygienists (ACGIH) TLV booklet can be used.

To monitor the worker, measure:

1. Heart rate: Count the radial pulse during a 30-second period as early as possible in the rest period.
    - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one third and keep the rest period the same.
    - If the heart rate exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one third.

2. Oral Temperature: Use a clinical thermometer, three minutes under the tongue, or similar device to measure the oral temperature at the end of the work period (before drinking).
    - If oral temperature exceeds 99.5°F (37.6°C), shorten the next work cycle by one third without changing the rest period.

be drunk to replace lost sweat. When heavy sweating occurs, encourage the worker to drink more. The following strategies may be useful:

- Maintain water temperature at 50° to 60°F (10° to 16.6°C).
- Provide small disposable cups that hold about 4 ounces.
- Have workers drink 16 ounces of fluid (preferably water or dilute drinks) before beginning work.
- Urge workers to drink a cup or two every 15 to 20 minutes or at each monitoring break. A total of 1 to 1.6 gallons of fluid per day are recommended, but more may be necessary to maintain body weight.

4. Train workers to recognize the symptons of heat-related illnesses.

COLD STRESS MONITORING

MONITORING

Thermal injury due to cold exposure can become a problem for fiels personnel. Systemic cold exposure is referred to as hypothermia. Local cold exposure is generally labeled frostbite.

Hypothermia is defined as a decrease in the patient core temperature below 96°F. The body temperature is normally maintained by a combination of central (brain and spinal cord) and peripheral (skin and muscle) activity. Interferences with any of these mechanisms can result in hypothermia, even in the absence of what is normally considered a "cold" ambient temperature. Symptoms of hypothermia include shivering, apathy, listlessness, sleepiness, and unconsiousness.

*Frostbite*is both a general and medical term given to areas of local cold injury. Unlike systemic hypothermia, frostbite rarely occurs unless ambient temperatures are less than freezing and usually less than 20°F. Symptoms of frostbite are a sudden blanching or whitening of the skin; the skin has a waxy or white appearance and is firm to the touch; tissues are cold, pale, and solid.

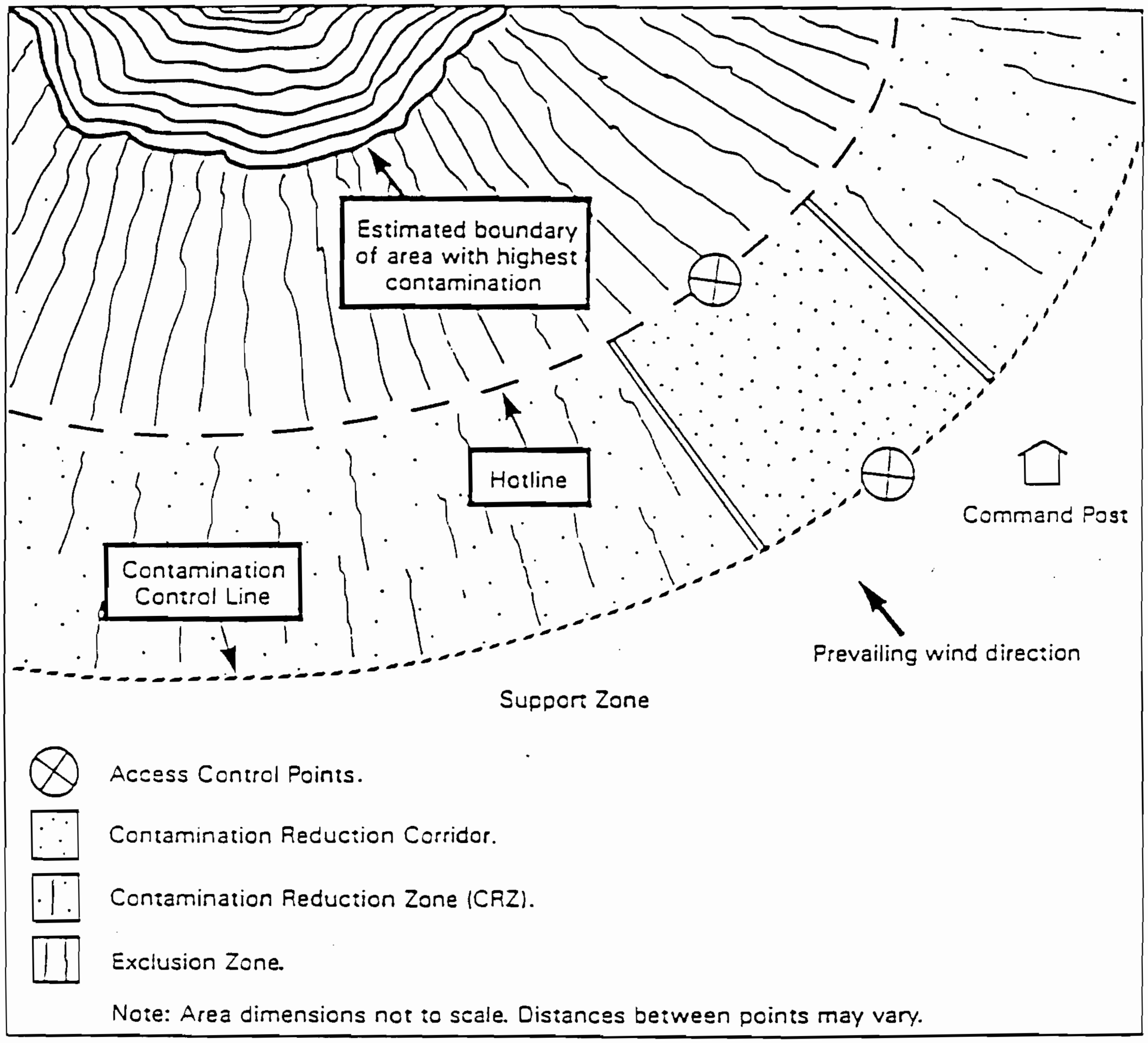
To monitor for cold stress: Start oral temperature recording at the job site:

1. At the Field Team Leader's discretion when suspicion is based on changes in worker's performance or mental status.
2. At worker's request.
3. As a screening measure, two (2) times per shift, under unusually harsh conditions (wind-chill less than 20°F or wind-chill less than 30°F with precipitation).
4. As a screening measure whenever any one worker on the site develops hypothermia.

PREVENTION OF COLD-RELATED ILLENESSES

1. Educate worker to recognize the symptoms of frostbite and hypothermia.

APPENDIX III



Site Work Zones. (Note that decontamination facilities are located in the Contamination Reduction Zone.)

APPENDIX IV

PERSONAL PROTECTIVE EQUIPMENT GUIDE

PROTECTIVE EQUIPMENT	PROTECTION LEVELS			
	A	B	C	D
Pressure demand, full face-piece, self-contained breathing apparatus (SCBA), or pressure-demand supplied air respirator with escape SCBA approved by NIOSH	●	●		
Totally-encapsulating chemical protective suit	●			
Full-face or half-mask, air purifying, canister equipped respirators (NIOSH approved)			●	
Escape mask (optional, as applicable)			●	●
Coveralls				●
Coveralls (optional, as applicable)	●	●	●	
Long underwear (optional, as applicable)	●			
Gloves (optional, as applicable)				●
Gloves, outer, chemical-resistant	●	●	●	
Gloves, inner, chemical-resistant	●	●	●	
Boots, outer, chemical-resistant, steel toe & shank		●	●	
Boots, chemical-resistant, steel toe & shank	●			
Boots, outer, chemical-resistant (disposable, as applicable)				●
Boot-covers, outer, chemical-resistant (disposable optional)		●	●	
Boots/shoes, chemical-resistant steel toe & shank				●
Hard hat (under suit, optional, as applicable)	●			
Hard hat		●	●	●
Disposable protective suit, gloves, and boots (may be worn over totally-encapsulating suit)	●			
Two-way radios (inside encapsulating suit, or under outside protective clothing for Level C)	●	●	●	
Face shield (optional, as applicable)		●	●	●
Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls)		●		
Hooded chemical-resistant clothing (overalls; two-piece chemical-splash suit; disposable chemical-resistant overalls)			●	
Safety glasses or chemical splash goggles				●

Level C Personal Protective Equipment

___ Coverall (Tyvek) White Poly Chemical

___ Neoprene / Chemically Resistant Gloves

___ Disposable Rubber Boots

___ Hardhat

___ Faceshield

___ Negative Pressure Respirator half face full face

*PPE can be obtained from Jholee Magee X4510. Checklists will be kept in project notebook or with HASP for the site.

APPENDIX V

Process: DECONTAMINATION PROCEDURES

INTRODUCTION

1.1 The objective of these procedures is to minimize the risk of exposure to hazardous substances. These procedures were derived from the U.S. Environmental Protection Agency, Office of Emergency and Remedial Response's (OERR), "Interim Standard Operating Safety Guides (revised Sep. 82)". This version of the guides is in a format that is more appropriate for use in the field.

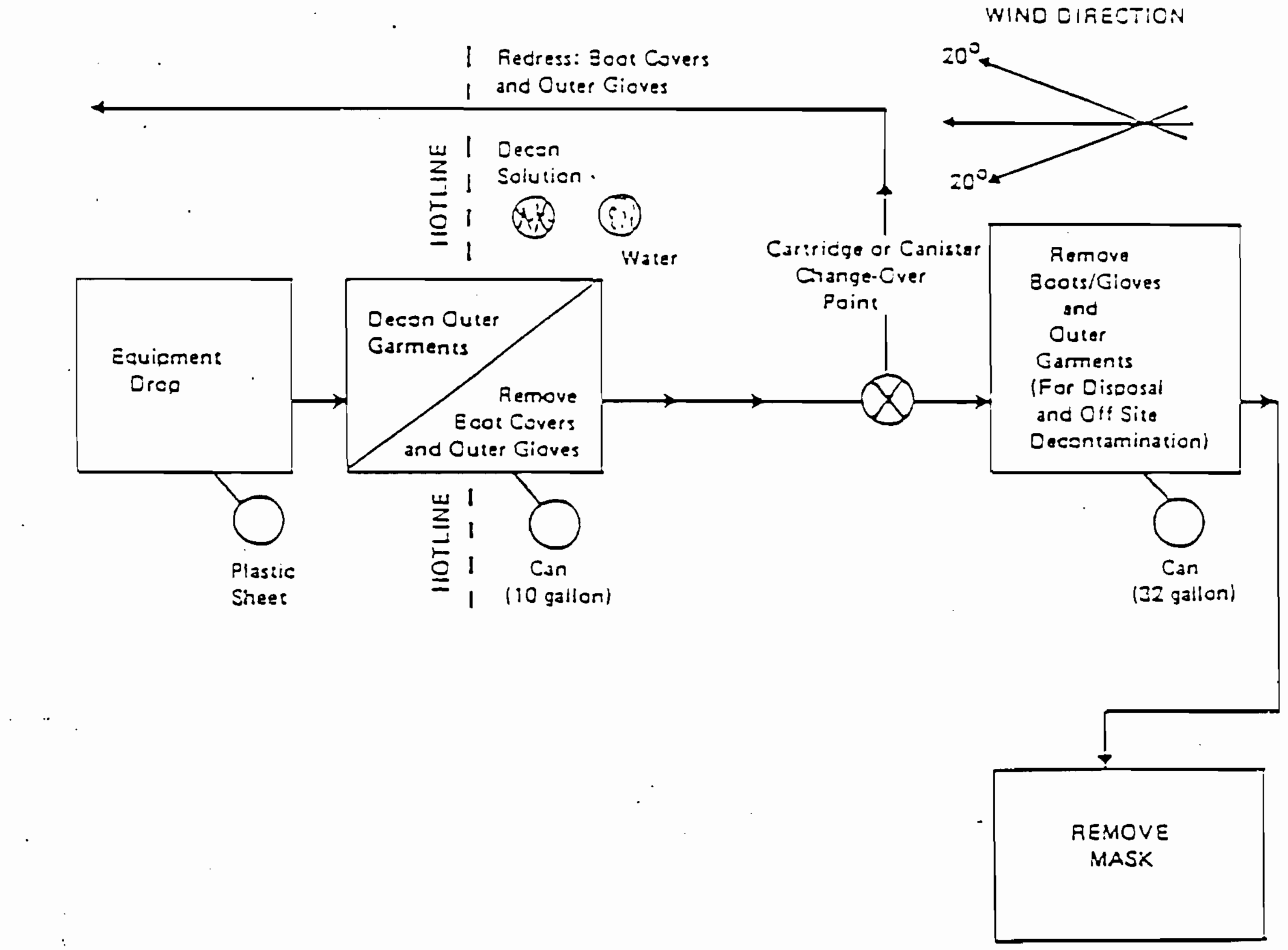
1.2 Protective equipment must be worn by personnel when response activities involve known or suspected hazardous substances. The procedures for decontaminating personnel upon leaving the contaminated area are addressed for each of the EPA, OERR designated levels of protection. The procedures given are for the maximum and minimum amount of decontamination used for each level of protection.

1.3 The maximum decontamination procedures for all levels of protection consist of specific activities at nineteen stations. Each station emphasizes an important aspect of decontamination. When establishing a decontamination line, each aspect should be incorporated separately or combined with other aspects into a procedure with fewer steps (such as the Minimum Decontamination Procedures).

1.4 Decontamination lines are site specific since they are dependent upon the types of contamination and the type of work activities on site. A cooling station is sometimes necessary within the decontamination line during hot weather. It is usually a location in a shaded area in which the wind can help to cool personnel. In addition, site conditions may permit the use of cooling devices such as cool water hose, ice packs, cool towels, etc. When the decontamination line is no longer required, contaminated wash and rinse solutions and contaminated articles must be contained and disposed of as hazardous wastes in compliance with state and federal regulations.

MINIMUM DECONTAMINATION LAYOUT

LEVEL C PROTECTION



MAXIMUM MEASURES FOR LEVEL C DECONTAMINATION

Station 1:	Segrated Equipment Drop	1. Deposit equipment used on site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Segregation at the drop reduces the probability of cross contamination. During hot weather operations, a cool down station may be set up within this area.
Station 2:	Boot Cover and Glove Wash	2. Scrub outer boot covers and gloves with decon solution or detergent and water.
Station 3:	Boot Cover and Glove Rinse	3. Rinse off decon solution from station 2 using copious amounts of water.
Station 4:	Tape Removal	4. Remove tape around boots and gloves and deposit in container with plastic liner.
Station 5:	Boot Cover Removal	5. Remove boot covers and deposit in containers with plastic liner.
Station 6:	Outer Glove Removal	6. Remove outer gloves and deposit in container with plastic liner.
Station 7:	Suit and Boot Wash	7. Wash splash suit, gloves, and safety boots. Scrub with long-handle scrub brush and decon solution.
Station 8:	Suit and Boot, and Glove Rinse	8. Rinse off decon solution using water. Repeat as many times as necessary.
Station 9:	Canister or Mask Change	9. If worker leaves exclusion zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boot covers donned, and joints taped worker returns to duty.
Station 10:	Safety Boot Removal	10. Remove safety boots and deposit in container with plastic liner.
Station 11:	Splash Suit Removal	11. With assistance of helper, remove splash suit. Deposit in container with plastic liner.
Station 12:	Inner Glove Rinse	12. Wash inner gloves with decon solution.
Station 13:	Inner Glove Wash	13. Rinse inner gloves with water.
Station 14:	Face Piece Removal	14. Remove face piece. Deposit in container with plastic liner. Avoid touching face with fingers.
Station 15:	Inner Glove Removal	15. Remove inner gloves and deposit in lined container.

APPENDIX VI

Genium Publishing Corporation
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Schenectady, NY 12304-4690 USA
(518) 377-8854

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.

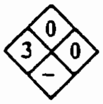
Powder

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 µg/m³

1992 OSHA SECAL*
TWA: 15 or 50 µg/m³

1990 IDLH Level
50 mg/m³

1993-94 ACGIH TLVs
TWA: 0.01 mg/m³ (total dust), Class A2 carcinogen
TWA: 0.002 mg/m³ (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/m³/20 min caused cardiac changes, thrombosis, and respiratory depression.
Rat, oral, LD_{50}: 225 mg/kg; details not reported.
Woman, inhalation, LC_{Lo}: 129 µg/m³ for 20 continuous years produced lung tumors.
Man, TC_{Lo}: 88 µg/m³/8.6 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 µg/m³ 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

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: β-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†

* Solid metal, † Powder

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:

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

Material Safety Data Sheet

From Genium's Reference Collection

Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8855

GENIUM PUBLISHING CORP.

No. 136

SELENIUM

Issued: April 1988

SECTION 1. MATERIAL IDENTIFICATION

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).

Not Found

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

SECTION 2. INGREDIENTS AND HAZARDS

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.

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.

Prepared by PJ Igoe, BS

Industrial Hygiene Review: DJ Wilson, CIH

Medical Review: MJ Hardies, MD

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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.

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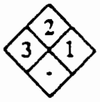

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Section 2. Ingredients and Occupational Exposure Limits

Manganese, ca 100%

OSHA PEL
Ceiling limit: 5 mg/m^3 (manganese compounds, as Mn)

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

NIOSH REL, 1987
Ceiling limit: 5 mg/m^3 (manganese and compounds, as Mn)
Toxicity Data*
Human, inhalation, TC_{Lo}: 2300 $\mu g/m^3$

* 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.

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. 713
Lead (Inorganic)

Issued: 8/90

Section 1. Material Identification

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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.

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.

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Cautions: *Inorganic lead is a potent systemic poison.* Organic lead (for example, tetraethyl lead) has severe, but different, health effects. 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

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. 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

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S 4
K 4

NFPA

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/m^3)
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/m^3/5 yr caused spermatogenesis.
Human, inhalation, TC: Continuous exposure to 300 mg/m^3 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.

Continue on next page

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 pneumoconiosis. **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

Material Safety Data Sheet

From Genium's Reference Collection
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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

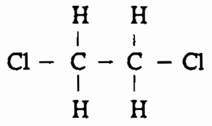
COMMENTS: Ethylene dichloride is a flammable, toxic liquid.

HMIS
H 1
F 3
R 0
PPE*
* See Sect. 8

R 1
I 4
S 2
K 4

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	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



$$\mathrm{Cl-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-Cl}$$

*The maximum allowable peak concentration (above the ceiling level value) of ethylene dichloride is 200 ppm for 5 minutes in any 3-hour period.

COMMENTS: Additional data concerning toxic doses and tumorigenic, reproductive, and mutagenic effects is listed (with references) in the NIOSH *RTECS* 1983-84 supplement, pages 865-66.

SECTION 3. PHYSICAL DATA

Boiling Point ... 182.3°F (83.5°C)
Vapor Pressure ... 87 Torr at 77°F (25°C)
Water Solubility ... Soluble in about 120 Parts Water
Vapor Density (Air = 1) ... 3.4

Evaporation Rate (n-BuAc = 1) ... Not Listed
Specific Gravity ... 1.2569 at 69°F (20°C)
Freezing Point ... -31.9°F (-35.5°C)
Molecular Weight ... 98.96 Grams/Mole

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

COMMENTS: Ethylene dichloride is miscible with alcohol, chloroform, and ether.

SECTION 4. FIRE AND EXPLOSION DATA

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

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

COMMENTS: Flash Point and Method: 56°F (13°C) CC; 65°F (18°C) OC.
OSHA Flammability Class (29 CFR 1910.106): IB. DOT Flammability Class (49 CFR 173.115): Flammable Liquid

SECTION 5. REACTIVITY DATA

Ethylene dichloride is stable. Hazardous polymerization cannot occur.

CHEMICAL INCOMPATIBILITIES include strong oxidizing agents. Explosions have occurred with mixtures of this material and liquid ammonia or dimethylaminopropylamine. Finely divided aluminum or magnesium metal may be hazardous in contact with ethylene dichloride.

CONDITIONS TO AVOID: Eliminate sources of ignition such as excessive heat, open flames, or electrical sparks, particularly in low-lying areas, because the explosive, heavier-than-air vapors will concentrate there.

PRODUCTS OF HAZARDOUS DECOMPOSITION can include vinyl chloride, chloride fumes, and phosgene. Phosgene is an extremely poisonous gas. Products of thermal-oxidative degradation (i.e., fire conditions) must be treated with appropriate caution.

SECTION 6. HEALTH HAZARD INFORMATION

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

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

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

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

EPA Hazardous Waste Number (40 CFR 261.33): U077
EPA Reportable Quantity (40 CFR 117.3): 5000 lbs (2270 kgs)
Aquatic Toxicity Rating, TLm 96: 1000 - 100 ppm

SECTION 8. SPECIAL PROTECTION INFORMATION

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

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

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

TRANSPORTATION DATA (per 49 CFR 172.101-2):

DOT Hazard Class: Flammable Liquid
DOT Label: Flammable Liquid
IMO Class: 3.2

DOT Shipping Name: Ethylene Dichloride
DOT ID No. UN 1184
IMO Label: Flammable Liquid, Poison

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

Approvals
Indust. Hygiene/Safety 11-18-87
Medical Review 11-30-87

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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

32

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
2
2 0
-

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/m^3

1987 IDLH Level
1700 ppm

1989-90 ACGIH
TLV-STEL (ceiling): 50 ppm, 301 mg/m^3

1988 NIOSH REL
None established

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

* 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/m^3; o-dichlorobenzene is irritating at 150 mg/m^3. 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^-).

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 Sheets Collection:
Sheet No. 317
Toluene
Issued: 8/79 Revision: E, 9/92

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.

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.

R 1
I 3
S 2*
K 3
* Skin absorption

NFPA

HMIS
H 2- Chronic effects
F 3
R 0
PPE-Sec. 8

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 page

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 < 100 ppm, use any chemical cartridge respirator with appropriate organic vapor cartridges, any supplied-air respirator (SAR), or SCBA. For < 200 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	**Packaging Authorizations**	**Quantity Limitations**	**Vessel Stowage Requirements**
DOT Hazard Class: 3	**a) Exceptions:** 150	**a) Passenger Aircraft or Railcar:** 5L	**Vessel Stowage:** B
ID No.: UN1294	**b) Non-bulk Packaging:** 202	**b) Cargo Aircraft Only:** 60L	**Other:** --
DOT Packing Group: II	**c) Bulk Packaging:** 242		
DOT Label: Flammable Liquid			
Special Provisions (172.102): T1			

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. 100
Aluminum Metal/Powder

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

Section 1. Material Identification

31

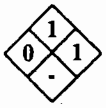
Aluminum Metal/Powder Description: The primary sources of aluminum are the ores cryolite and bauxite. Produced by electrolysis of bauxite in a bath of molten cryolite, or made synthetically from fluorspar. As pure metal or as alloys, aluminum is used for aircraft, building and construction materials, 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.

R 1
I 2
S 2
K 1

NFPA



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

Section 2. Ingredients and Occupational Exposure Limits

Aluminum metal/powder, ca 100%*

OSHA PELs	**ACGIH TLVs, 1989-90**	**NIOSH REL, 1987**
8-hr TWA: 5 mg/m^3 (respirable fraction, pyro powders, welding fumes)	TLV-TWA: 5 mg/m^3 (pyro powders, welding fumes)	None established
8-hr TWA: 15 mg/m^3 (total dust)	TLV-TWA: 10 mg/m^3 (metal dust)	**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/ft^3	**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/m^3 or greater can cause "metal fume fever."

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

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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

30

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

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

Section 2. Ingredients and Occupational Exposure Limits

Antimony, ca 99%

OSHA PEL	ACGIH TLV, 1989-90	NIOSH REL, 1987*	Toxicity Data†
8-hr TWA: 0.5 mg/m³ (as Sb)	TLV-TWA: 0.5 mg/m³ (as Sb)	10-hr TWA: 0.5 mg/m³	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.

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 Sheet Collection

Arsenic Pentoxide **MSDS No. 193**

Date of Preparation: 6/86 Revision: A, 4/95

Section 1 - Chemical Product and Company Identification 46

Product/Chemical Name: Arsenic Pentoxide
Chemical Formula: As_2O_5
CAS Number: 1303-28-2
Synonyms: arsenic acid anhydride, arsenic anhydride, arsenic oxide, arsenic (V) oxide, arsenic pentaoxide, arsenic pentoxide, diarsenic pentoxide, orthoarsenic acid, Zotox
Derivation: By the reaction of arsenic trioxide and nitric acid followed by dehydration of the intermediate orthoarsenic acid hydrate or by the action of an oxidizing agent such as nitric acid on arsenious oxide.
General Use: In wood preservatives, weed control, adhesives for metals; in the manufacture of colored glass, linoleum, electrical semiconductors and pyrotechnics; in dyeing and printing; as a leather hide depilatory; and as a chemical intermediate for metal arsenates.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Arsenic Pentoxide, ca 100 %wt

OSHA PEL
8-hr TWA: 0.01 mg/m^3, inorganic compounds (except arsine), as As
29 CFR 1910.1018

IDLH Level
5 mg/m^3 (as As)

NIOSH REL
Ca-inorganic compounds, as As*
15-min TWA Ceiling: 0.002 mg/m^3

ACGIH TLV
TWA: 0.01 mg/m^3, inorganic compounds (except arsine), as As
TLV-A1: Confirmed Human Carcinogen

DFG (Germany) MAK
None established

* NIOSH recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration.

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Arsenic pentoxide exists as white amorphous lumps or powder; odorless. Poisonous! Severe acute arsenic poisoning from occupational exposure is rare. Acute arsenic poisoning results primarily from ingestion of contaminated food and drink. Chronic inhalation of inorganic arsenic compounds is the most common cause of industrial poisoning. It is irritating to the skin, eyes, and respiratory tract and causes skin sensitization. Arsenic and its inorganic compounds are carcinogenic to humans.

Wilson Risk Scale	
R	2
I	4
S	3
K	1

HMIS	
H	3*
F	0
R	0

* Chronic effects
PPE†
†Sec. 8

Potential Health Effects

Primary Entry Routes: Dust inhalation, skin/eye contact, and ingestion.
Target Organs: Liver, skin, lungs, and the cardiovascular (heart), lymphatic, central nervous, and peripheral nervous systems.
Acute Effects
Inhalation: Irritation of the mucous membranes, nose, and throat which may lead to laryngitis, bronchitis, or rhinitis (runny nose). Exposure to very high concentrations may cause nasal ulceration and perforation of the nasal septum (a hole in the inner nose), nausea, vomiting, and diarrhea. Pulmonary edema and respiratory failure may develop with severe poisoning.
Eye: Irritation, conjunctivitis, itching, burning, and watering of eyes.
Skin: Contact dermatitis with burning, itching, irritation, folliculitis, redness and swelling, rash, papules and vesicles in more severe cases, and sensitization.
Ingestion: Sweetish metallic taste, garlicky odor of breath and feces, burning lips, constriction of the throat, difficulty in swallowing, excruciating abdominal pain, severe nausea, projectile vomiting, profuse diarrhea followed by bloody feces, dehydration with intense thirst, and muscular cramps. Other toxic effects may occur of the liver (usually after acute exposures to higher doses), the blood-forming organs (break up of red blood cells, reduced oxygen-carrying proteins), the cardiovascular system (heart muscle stopping and rhythm abnormalities), and central and peripheral nervous systems. High-dose exposures (1 mg As/kg/day or above) often lead to encephalopathy with headache, lethargy, mental confusion, hallucinations, and coma. In severe cases, death may ensue from fluid loss and circulatory collapse.
Carcinogenicity: IARC, NTP, OSHA, and EPA list inorganic arsenic compounds (as As) as IARC-1 (carcinogenic to humans: sufficient evidence of carcinogenicity), NTP-1 (known to be carcinogenic: sufficient evidence from human studies), OSHA-X (carcinogen defined with no further categorization), and EPA-A (human carcinogen: sufficient evidence from epidemiological studies to support a causal association between exposure and cancer), respectively. The DFG classifies arsenic pentoxide as

MAK-A1 (capable of inducing malignant tumors as shown by experience with humans). Arsenic may cause cancer of the lung, skin, larynx, lymphoid system, or viscera (internal organs of the body: liver, bladder, kidneys).

Medical Conditions Aggravated by Long-Term Exposure: Respiratory tract, skin, liver, kidney or neurological disorders.

Chronic Effects: Chronic skin contact and inhalation may cause thickened skin (hyperkeratosis), pigment changes, white lines on the nails (Mee's lines), and hyperkeratotic warts or corns on the palms and soles. Chronic ingestion may cause a swollen and tender liver and elevated levels of hepatic (liver) enzymes; peripheral neuropathy with numbness in the hands and feet, a painful "pins and needles" sensation, and muscle weakness, sometimes leading to wrist-drop or ankle-drop; pancytopenia (an abnormal reduction of RBCs, WBCs and blood platelets), aplastic anemia, leukopenia (abnormally low number of WBCs), bone marrow depression, or leukemia; and damage to the vascular system with a progressive loss of circulation in the hands and feet, leading ultimately to necrosis and gangrene. Chronic inhalation may cause weakness, loss of appetite, gastrointestinal disturbances, conjunctivitis, irritation of the throat and respiratory tract, hoarseness, and perforation of the nasal septum. Inhalation exposure to inorganic arsenic increases the risk of lung cancer and ingestion of inorganic arsenic increases the risk of developing skin and internal (mainly of liver, bladder, kidney, and lung) cancers.

Other: Inorganic arsenic crosses the placenta. Based on animal studies, high doses of ingested arsenic may be fetotoxic and weakly teratogenic (may cause damage to the fetus). There are reports of male reproductive effects in rats. Inorganic arsenicals are classified as either inactive or weak mutagens, but are able to produce chromosomal effects in most systems.

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 min. Consult a physician or ophthalmologist 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.

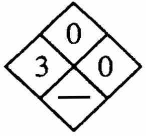
Note to Physicians: Determine CBC, electrolytes, urinalysis (including spot urine As and a 24 hr As collection), liver and renal function tests, and blood arsenic in all symptomatic patients. A chelated or nonchelated 24 hr urinary arsenic collection > 100 µg is usually abnormal. Obtain an abdominal radiograph in all patients who acutely ingested arsenic. Chelation therapy: treat with BAL 3 to 5 mg/kg dose IM every 4 to 12 hr. As symptoms and signs subside, change to oral D-penicillamine 100 mg/kg/day up to 2 g daily in four divided doses. If allergic to penicillamine, administer BAL for 5 days with tapering of the dose. In severely ill patients, consider combined therapy with both BAL and D-penicillamine. BAL also may be utilized to treat chronic arsenic intoxication. Meso-2,3-dimercaptosuccinic acid (DMSA) is an effective oral chelating agent and may be more effective and cause fewer side effects than BAL.

Special Precautions/Procedures: Emergency personnel should protect against contamination when aiding exposure victims.

Section 5 - Fire-Fighting Measures

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

NFPA



Extinguishing Media: Use flooding quantities of water as spray. Use extinguishing agents suitable for the surrounding fire.

Unusual Fire or Explosion Hazards: Under fire conditions, arsenic pentoxide may produce toxic arsine gas when in contact with metal and water.

Hazardous Combustion Products: Poisonous arsine gas and oxides of arsenic.

Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways. Isolate discharged material for proper disposal.

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 firefighter's protective clothing will provide limited protection.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, evacuate unnecessary personnel, and ventilate area. Cleanup personnel should protect against dust inhalation and skin or eye contact.

Small Spills: Carefully vacuum up spilled material (vacuum must have high-efficiency filters to prevent redispersion of dust). For liquid spills, neutralize with crushed limestone, soda ash, or lime and take up with an inert material such as vermiculite or sand, and place into appropriate containers for disposal.

Large Spills

Containment: Cover with plastic sheet to prevent dust dispersion. For large spills, dike far ahead of liquid spill for later disposal. Do not release into sewers or waterways. Alum floc ties up arsenic in insoluble form for easy removal and handling.

Cleanup: *Do not* sweep or brush material or use compressed air. Thoroughly wash spill area to remove all residues.

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

Section 7 - Handling and Storage

Handling Precautions: Avoid dust inhalation and ingestion. Practice meticulous personal hygiene and housekeeping procedures. Wash hands and face thoroughly before eating or smoking.

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from incompatibles (Sec. 10), food or food products, and combustible materials. Protect containers against physical damage. Floors should be of impermeable material and flushed frequently with water.

Regulatory Requirements: Refer to 29 CFR 1910.1018 for compliance requirements for inorganic arsenic.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Enclose all operations to prevent dust dispersion into the work area.

Ventilation: Provide general or 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)

Administrative Controls: Educate workers about the hazards of arsenic pentoxide and train in work practices which minimize exposure. Provide preplacement and periodic medical exams with emphasis on the skin, nasal passages, and lungs. Refer to 29 CFR 1910.1018 for the medical surveillance program requirements. Urinary levels of arsenic above 0.7 to 1.0 mg/L in exposed individuals may be indicative of harmful exposure. Dietary factors such as seafood consumption must be considered in background levels and are included in the BEI value of 50 µg/g creatinine (determinant: inorganic arsenic metabolites in urine; sampling time: end of workweek). Advise against seafood consumption for 48-72 hr prior to routine testing.

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. 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 any detectable concentration of inorganic arsenic (as As), wear any SCBA that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; or any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA 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. Refer to 29 CFR 1910.1018 for the respirator program requirements.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Skin may be coated with a silicone-based cream for increased protection. 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. *Do not* remove dust by blowing or shaking; use a vacuum cleaner with an appropriate filter. Launder before reuse. Shower at the end of the work shift. Remove arsenic pentoxide from your shoes and clean personal protective equipment. Dispose of inorganic arsenic contaminated wash water in accordance with applicable local, State, or Federal regulations.

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

Section 9 - Physical and Chemical Properties

Physical State: Solid

Appearance and Odor: White lumps or powder; odorless.

Formula Weight: 229.84

Density (H_2O=1, at 4 °C): 4.32

Water Solubility:* Soluble; 150 g/100 mL at 61 °F (16 °C); 76.7 g/100 mL at 212 °F (100 °C)

Other Solubilities: Soluble in alcohol, acid, and alkali.

Boiling Point: Decomposes

Melting Point: 599 °F (315 °C); decomposes

* Combines very slowly with water to form arsenic acid (H_3AsO_4)

Section 10 - Stability and Reactivity

Stability: Arsenic pentoxide is stable at room temperature in closed containers under normal storage and handling conditions. It is thermally unstable and gradually deliquesces on exposure to air.

Polymerization: Hazardous polymerization does not occur.

Chemical Incompatibilities: Acids, halogens, aluminum, and zinc. It is corrosive to metals in the presence of moisture. When water solutions of arsenicals are in contact with active metals (iron, aluminum, zinc), highly toxic arsenic fumes are released. Contact with bromine pentafluoride is violent, with ignition often occurring.

Conditions to Avoid: Avoid contact with incompatibles and exposure to heat and ignition sources.

Hazardous Decomposition Products: Thermal oxidative decomposition of arsenic pentoxide can produce poisonous arsine gas and arsenic oxides.

Section 11 - Toxicological Information

Toxicity Data:*

Acute Oral Effects:
Rat, oral, LD_{50}: 8 mg/kg

Genetic Effects:
Human, fibroblast: 100 µmol/L caused DNA inhibition.
Human, leukocyte: 1200 nmol/L; cytogenetic analysis.

* See NIOSH, *RTECS* (CG2275000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Grasshopper, oral, LD_{50}: 0.9-25.6 ppm/7 days; 1.0-5.5 ppm/14 days.

Environmental Transport: Bioconcentration of arsenic occurs in aquatic organisms, primarily in algae and lower invertebrates. Bioconcentration factors (BCFs) measured in freshwater invertebrates and fish ranged from 0 to 17; a BCF of 350 was observed in marine oysters. Biomagnification in aquatic food chains does not appear to be significant.

Environmental Degradation: Arsenic in water can undergo a complex series of transformations including biotransformation, ligand exchange, and oxidation-reduction reactions. The factors most strongly influencing fate processes in water include pH; iron, metal sulfide, and sulfide ion concentrations; temperature, salinity and distribution and composition of the biota. In air, photolysis is not considered an important fate process for arsenic compounds.

Soil Absorption/Mobility: Arsenic compounds tend to adsorb to soils or sediments and leaching usually results in transportation over only short distances in soil.

Section 13 - Disposal Considerations

Disposal: Thermal destruction or discharge to sewer is not recommended. Consider methods involving precipitation, conversion to the insoluble sulfide, solidification, and disposal in a landfill. 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 wash water in accordance with applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Arsenic pentoxide
Shipping Symbols: —
Hazard Class: 6.1
ID No.: UN1559
Packing Group: II
Label: Poison
Special Provisions (172.102): —

Packaging Authorizations
- a) **Exceptions:** None
- b) **Non-bulk Packaging:** 173.212
- c) **Bulk Packaging:** 173.242

Quantity Limitations
- a) **Passenger, Aircraft, or Railcar:** 25 kg
- b) **Cargo Aircraft Only:** 100 kg

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

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. P011
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per RCRA, Sec. 3001 and CWA, Sec. 311 (b)(4)
CERCLA Reportable Quantity (RQ), 1 lb (0.454 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65), as arsenic compounds
Listed as a SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Threshold Planning Quantity (TPQ): 100/10,000 lb

OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)
Listed as an OSHA Specifically Regulated Substance (29 CFR 1910.1018), as inorganic arsenic

Section 16 - Other Information

References: 73, 100, 103, 124, 136, 167, 176, 189, 197, 200, 201, 202, 204, 205.

Prepared By MJ Wurth, BS **Industrial Hygiene Review** PA Roy, MPH, CIH **Medical Review** R Teichman, 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

Beryllium Metal/Powder Description: A naturally occurring ore found in chrysoberyl (Be_2SiO_4) or produced industrially from beryl ($3Be.OAl_2O_3.6SiO_2$). 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.

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Section 2. Ingredients and Occupational Exposure Limits

Beryllium and compounds, ca 100%

OSHA PELs	**ACGIH TLV, 1989-90***	**Toxicity Data†**
8-hr TWA: 0.002 ppm	TLV-TWA: 0.002 mg/m³	Human, inhalation, TC_{Lo}: 300 mg/m³, pulmonary effects
30-min STEL: 0.005 ppm	**NIOSH REL, 1987***	Rabbit, intravenous, TD_{Lo}: 20 mg/kg, neoplastic effects
Ceiling level: 0.025 ppm	Not to exceed 0.5 µg/m³	

* 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

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-$\mu g/m^3$ 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/m^3 (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/m^3. A full facepiece, air-purifying respirator with a high-efficiency filter is suitable for concentrations up to 100 μg Be/m^3. 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/m^3. An SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode is suitable for concentrations above 1000 μg Be/m^3. 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

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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.

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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 flurotrichloroethane. 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.

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 carcinogen.

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 compounds 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, cover 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

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Material Safety Data Sheets Collection:

Sheet No. 162
Copper

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

Section 1. Material Identification

32

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.

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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*(73) 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/m^3* 8-hr TWA: 0.1 mg/m^3†	TLV-TWA: 1 mg/m^3* TLV-TWA: 0.2 mg/m^3†	None established	Human, oral, TD_{Lo}: 120 µg/kg affects the gastrointestinal tract (nausea or vomiting) 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).

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

Material Safety Data Sheet

From Genium's Reference Collection

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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.

Not Found

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

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
Cobalt Metal/Powder, CAS No. 7440-48-4 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.	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

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 % by Volume	LOWER	UPPER
*	*		*	*

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.

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. PJI

Prepared by PJ Igoe, BS
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Medical Review: MJ Hardies, MD

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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
K	1

Genium

HMIS

H	2
F	1
R	1
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/m^3	TLV-TWA: 0.5 mg/m^3	8-hr TWA (for chromium metal and insoluble salts): 1 mg Cr/m^3	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 $^{+6}$/m^3. 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/m^3; for noncarcinogenic Cr^{+6} compounds (including chromic acid), the RELs (10-hr TWAs) are 25 µg/m^3 and 50 µg/m^3 (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/ft^3	**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.

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 incresed 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 vomoting. 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

M8

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Material Safety Data Sheet Collection

Calcium Metal **MSDS No. 221**

Date of Preparation: 11/87 Revision: A, 3/97

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: Calcium Metal
Chemical Formula: Ca
CAS Number: 7440-70-2
Synonym: Calcicat
Derivation: Produced by thermal vacuum reduction of lime with aluminum, or by electrolysis of calcium chloride. Redistillation produces calcium with 99%+ purity.
General Use: Used as a deoxidizer for copper, beryllium and steel; also used in the decarburization and desulfurization of iron and its alloys; as a "getter" in the production of electronic vacuum tubes; and as a fertilizer ingredient.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Calcium , 99+% wt
Trace Impurities: Mg, N, Al, Fe, Co, Li, Be, Cr, Mn, and B

OSHA PEL
None established

NIOSH REL
None established

DFG (Germany) MAK
None established

ACGIH TLV
None established

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Calcium metal is a lustrous silver-white metal that is relatively soft, though much harder than sodium. It is harmful to the respiratory tract if inhaled and contact may cause burns to skin and eyes. Calcium metal dust is flammable and may ignite if exposed to heat, acids or moisture.

Potential Health Effects

Primary Entry Routes: Inhalation, eye and skin contact
Target Organs: Eyes, skin and respiratory system
Acute Effects
Inhalation: Inhalation of calcium dust can cause respiratory tract irritation.
Eye: Contact can severely burn eyes.
Skin: Contact can severely burn skin.
Ingestion: Ingestion can severely burn mucous membranes.
Carcinogenicity: IARC, NTP, and OSHA do not list calcium as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Chronic Effects: Long-term exposure to calcium metal dust may affect the lungs, but is not known to cause lung damage.

Wilson Risk Scale	
R	2
I	-
S	4
K	4

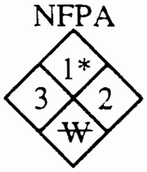
HMIS	
H	3*
F	1
R	2
PPE†	

* Chronic effects
† Sec. 8

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 or ophthalmologist 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.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Treat symptomatically and supportively.

Section 5 - Fire-Fighting Measures



Flash Point: Calcium metal does not have a flash point by standard methods. Calcium metal dust does form flammable mixtures with air. When exposed to moist air, finely divided calcium metal may ignite spontaneously at room temperature.
Autoignition Temperature: None reported.
LEL: None reported
UEL: None reported.
Flammability Classification: Calcium metal is a flammable solid.
Extinguishing Media: Do not use water, halogenated hydrocarbons (CCl_4) 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: Flammable when finely divided; reacts with water to liberate hydrogen.
Hazardous Combustion Products: Calcium oxide (CaO_x) fumes which can react with water to produce heat, calcium hydroxide (CaOH) which is corrosive, and flammable hydrogen (H_2) gas.
Fire-Fighting Instructions: Move containers from fire area if it can be done without risk. Cool fire-exposed containers with water until well after fire is out. *Do not* get water inside containers. 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. SCBA and structural firefighter's protective clothing provide limited protection.

*As finely divided calcium dust, Genium would rate flammability a 3 based on NFPA criteria.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate, and deny entry. Shut off ignition sources. *Do not* touch spilled material. *Do not* put water on spilled material or get water inside container. Cleanup personnel should protect against dust inhalation and skin and eye contact.
Small Spills: Keep water away from spills. Carefully scoop up spilled calcium metal with a shovel and place in clean containers. Seal containers for future disposal or reclamation.
Large Spills
Containment: For large spills, dike far ahead of spill for later disposal. Cover with plastic sheet to avoid further dust dispersion. *Do not* release into sewers or waterways.
Cleanup: Use nonsparking tools. *Do not* dry sweep.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Avoid dust inhalation and skin and eye contact. Wear protective clothing, gloves, goggles and full face shield. Keep calcium metal away from moisture and strong oxidizers.
Storage Requirements: Store in tightly closed containers in a cool, well-ventilated area away from moisture, oxidizers and acids. Store calcium in kerosene or other neutral oil. Protect containers against physical damage. Never store under halogenated hydrocarbons. Detached storage in fire-resistant building is recommended.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Keep calcium metal away from water and high temperatures. To prevent static sparks, electrically ground and bond all equipment used around calcium metal. Where feasible, enclose operations to prevent dust dispersion into the work area.
Ventilation: Enclose operations using calcium metal and use local exhaust ventilation. 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. Perform lung function tests as necessary. Educate workers about the hazards associated with calcium. Train in work practices which minimize exposure.
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. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. Use a full-face respirator to provide eye protection. 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 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: Lustrous, silver-white surface, face centered cubic structure below 572 °F (300 °C)
Vapor Pressure: 10 mm Hg at 1801 °F (983 °C)
Formula Weight: 40.08
Density (H_2O=1, at 4 °C): 1.54 at 20 °C
Water Solubility: Reacts exothermically with water; may evolve explosive hydrogen gas.
Other Solubilities: Soluble in acid, liquid ammonia; slightly soluble in alcohol.
Insolubilities: Benzene and kerosene
Boiling Point: 2624 °F (1440 °C)
Melting Point: 1562 °F (850 °C)
Brinell Hardness: 17
Electrical Resistivity: 3.5 µohm at 68 °F (20 °C)
Heat of Combustion: 151.9 cal/g

Section 10 - Stability and Reactivity

Stability: Calcium is stable at room temperature in closed containers under normal storage and handling conditions. It oxidizes in air to form an adherent, protective, oxide/nitride film (CaO/Ca_3N_2).
Polymerization: Hazardous polymerization does not occur.
Chemical Incompatibilities: Incompatible with air. Reacts violently with water to form hydroxide and explosive hydrogen. Violent reaction with mercury (at 734 °F/390 °C); silicon (above 1922 °F/1050 °C); sodium + mixed oxides + heat. Potentially explosive reaction with alkali metal hydroxides or carbonates; dinitrogen tetraoxide; lead chloride + heat; phosphorus (V) oxide + heat; sulfur + heat. Molten calcium reacts explosively with asbestos cement. Hypergolic reaction with chlorine fluorides (e.g., chlorine trifluoride; chlorine pentafluoride). Ignition on contact with halogens (e.g., fluorine, chlorine); sulfur + vanadium (V) oxide.
Conditions to Avoid: Exposure to moisture, heat, ignition sources and incompatibles.
Hazardous Decomposition Products: Thermal oxidative decomposition of calcium metal can produce calcium oxides (CaO_x), which can react with water to produce calcium hydroxide (CaOH) and hydrogen (H_2).

Section 11 - Toxicological Information

Toxicity Data: None listed*

* Monitor NIOSH, *RTECS* (EV8040000), for future toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Data not found.
Environmental Fate: Data not found.

Section 13 - Disposal Considerations

Disposal: 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: Calcium
Shipping Symbols: –
Hazard Class: 4.3
ID No.: UN1401
Packing Group: II
Label: DANGEROUS WHEN WET
Special Provisions (172.102): B101, B106

Packaging Authorizations
- a) **Exceptions:** None
- b) **Non-bulk Packaging:** 173.212
- c) **Bulk Packaging:** 173.241

Quantity Limitations
- a) **Passenger, Aircraft, or Rail car:** 15 kg
- b) **Cargo Aircraft Only:** 50 kg

Vessel Stowage Requirements
- a) **Vessel Stowage:** E
- b) **Other:** –

Section 15 - Regulatory Information

EPA Regulations:
Calcium metal dust is classified as a RCRA Hazardous Waste (40 CFR 261.23): Characteristic of Reactivity
CERCLA Hazardous Substance (40 CFR 302.4) listed as an, Unlisted Hazardous Waste Characteristic of Reactivity, specific 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:
Air Contaminant (29 CFR 1910.1000, Table Z-1): Not listed.

Section 16 - Other Information

References: 99, 124, 136, 149, 190, 197. 209

Prepared By .... M Carlson, BA/MJ Wurth, BS
Industrial Hygiene Review .... DJ Wilson, CIH
Medical Review .... T Thoburn, MD, MPH

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Material Safety Data Sheet Collection

Magnesium Metal **MSDS No. 216**

Date of Preparation: 8/87 Revision: A, 3/97

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: Magnesium
Chemical Formula: Mg
CAS Number: 7439-95-4
Synonyms: magnesium powdered, magnesium sheet
Derivation: By the reduction of magnesium oxide with ferrosilicon (Pidgeon process) or by electrolysis of fused magnesium chloride (Dow sea water process).
General Use: In aluminum alloys for structural parts, diecast auto parts, space vehicles, missiles; in the production of zirconium, titanium, zinc, nickel, and iron; as a powder for flash photography and pyrotechnics; in anti-knock gasoline additives, cathodic protection, desulfurizing iron in steel manufacture, dry and wet batteries, precision instruments, and optical mirrors; as a reducing agent; and in magnesium compounds and Grignard syntheses.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Magnesium, 99.9% wt
Trace Impurities: aluminum, copper, iron, manganese, nickel, and silicon

OSHA PEL*	ACGIH TLV	NIOSH REL	DFG (Germany) MAK
None established	None established	None established	None established

* Although no occupational exposure limits have been established for magnesium, do not assume it is harmless. Follow safe work practices.

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Magnesium is a silvery white metal; odorless. Dust and fume inhalation causes respiratory tract irritation. Inhalation of magnesium fumes causes metal fume fever. Molten metal causes thermal burns. Magnesium metal powder is a dangerous fire hazard when wet. It may ignite spontaneously. The powder also forms explosive mixtures with air which may be ignited by a spark.

Wilson Risk Scale
R 3
I 2
S 2
K 1

HMIS
H 2*
F 1
R 2
PPE†
*Chronic Effects
†Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin contact (with penetration of metal particles)
Target Organs: Respiratory tract, skin, eyes, digestive tract
Acute Effects
Inhalation: Dust inhalation causes irritation of the upper respiratory tract resulting in atrophic nasopharyngitis. Inhalation of magnesium fumes can 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).
Eye: Contact with dust may cause conjunctivitis. Fume irritates eyes.
Skin: 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). Molten magnesium causes thermal burns.
Ingestion: Highly unlikely route of exposure. However, ingestion of substantial amounts of magnesium may cause hypermagnesemia with nausea, vomiting, hypotension, ECG changes, and neuromuscular transmission impairment, drowsiness, sweating, unsteadiness, and respiratory paralysis..
Carcinogenicity: IARC, NTP, and OSHA do not list magnesium as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: Respiratory and digestive disorders.
Chronic Effects: May cause digestive disturbances including peptic ulcers. With overexposure to dust and fume, chronic respiratory irritation is expected.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air, monitor for respiratory distress, 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. Consult a physician or ophthalmologist if pain and/or irritation develop.

Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water to remove loose particles. 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 for significant ingestion. 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: Treat symptomatically and supportively. For cases of ingestion, monitor EKG and vital signs frequently. Hemodialysis is the most effective method to remove significant quantities of magnesium. Magnesium is more toxic if renal function is impaired.

Section 5 - Fire-Fighting Measures

Flash Point: The solid is difficult to ignite. Finely divided magnesium powder may be ignited by spark or flame or even spontaneously when damp.

Autoignition Temperature: None reported.

LEL: None reported.

UEL: None reported.

Extinguishing Media: *Do not* use water or foam. Use dry sand, sodium chloride powder, graphite powder, or Met-L-X ® powder.

Unusual Fire or Explosion Hazards: Magnesium may ignite itself if it is exposed to air or in the presence of moisture, particularly with water-oil emulsion. It may reignite itself after the fire is extinguished. Its violent reaction with water will generate flammable and explosive hydrogen.

Hazardous Combustion Products: Magnesium oxide

Fire-Fighting Instructions: Protect eyes and skin against flying particles. Avoid direct viewing of magnesium fires as eye injury may result. *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, evacuate all unnecessary personnel, remove heat and ignition and water sources, and isolate and ventilate area. Cleanup personnel should protect against dust and fume inhalation and skin and eye contact.

Small Spills: Carefully place in clean, dry, metal containers and remove to clean, dry storage. Keep away from water.

Large Spills

Containment: Cover with plastic sheet to prevent dispersion. *Do not* release into sewers or waterways.

Cleanup: Use nonsparking tools. *Do not* use water. *Do not* dry sweep.

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

Section 7 - Handling and Storage

Handling Precautions: Avoid dust and fume inhalation and contact with skin and eyes. Use with ventilation sufficient to reduce airborne concentrations to the lowest feasible level. Practice good personal hygiene procedures. Thoroughly wash after handling. Use nonsparking tools when working with or near magnesium. Prohibit open flames or electrical or gas cutting or welding equipment where magnesium dust is produced or handled. During machining, do not use dull cutting tools, rub tool on work after cutting operation is complete, or machine with light (thin) cuts at high speeds as magnesium fires may result.

Storage Requirements: Store finely divided chips or shavings in detached fire-resistive building. Protect from moisture and keep away from chlorine, bromine, iodine, acids, other incompatibles (see Sec. 10) and possible ignition sources. Protect molten magnesium by an atmosphere of sulfur dioxide gas.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Enclose operations and/or ventilate at the site of chemical release to prevent dust dispersion into the work area. To eliminate ignition sources, ground and bond all containers and equipment. Dust-ignition proof electrical equipment (Class II, Group E) is required. Construct buildings in which magnesium is cast or machined of nonflammable materials and without protuberances or ledges on which magnesium dust might accumulate. Collect magnesium grinding dust in a dust collector specifically approved for this purpose. Remove collected material frequently.

Ventilation: Provide general or 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)

Administrative Controls: Educate workers about the hazards associated with magnesium. Train in safe work practices. Practice good housekeeping procedures. Frequently collect magnesium turnings and borings, store them in a clean, dry, metal-covered container labeled "Magnesium Only."

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 equipped with particulate (dust/fume/mist) filters. For exposure to potentially high concentrations, use a supplied-air respirator with a full facepiece operated in the positive-pressure mode; or with a full facepiece, hood, or helmet in the continuous flow mode; or a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or other positive-pressure mode. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. 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. For casting the metal, wear leather aprons and hand protection to protect against the "spatter" of small particles. For machining or buffing, wear overalls to which small metal fragments will not adhere. Wear protective eyeglasses or chemical safety goggles and face shield, 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: Silvery white metal; odorless
Atomic Weight: 24.305
Vapor Pressure: 1 mm Hg at 1149.8 °F (621 °C)
Density: 1.738 g/cm^3 at 68 °F (20 °C)
Heat of Combustion: -11.950 Btu/lb
Heat of Fusion: 88 cal/g
Specific Heat: 0.245 cal/g at 68 °F (20 °C)

Water Solubility: Insoluble in cold water; slightly soluble with decomposition in hot water
Other Solubilities: Soluble in mineral acids; *insoluble* in chromium trioxides
Boiling Point: 2024.6 °F (1107 °C)
Freezing/Melting Point: 1202 °F (650 °C)
Electrical Resistivity: 4.46 µohm/cm

Section 10 - Stability and Reactivity

Stability: Magnesium is stable at room temperature in closed containers under normal storage and handling conditions. Magnesium slowly oxidizes in air. It is strongly attacked by salt air.

Polymerization: Hazardous polymerization cannot occur.

Chemical Incompatibilities: Reacts violently with water (evolves highly flammable hydrogen gas), chlorinated solvents, methanol, hydrogen peroxide, oxidizing agents, sulfur compounds, animal and vegetable oils, acids (evolves hydrogen), metal oxides, metal cyanides, metal oxide salts, oxygen, and tellurium compounds.

Conditions to Avoid: Contact with incompatibles (listed above) and heat and ignition sources.

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

Section 11- Toxicological Information

Toxicity Data:*

* Monitor NIOSH, *RTECS* (OM2100000), for future toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Data not found.

Environmental Fate: Data not found.

Section 13 - Disposal Considerations

Disposal: 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: Magnesium [or] magnesium alloys (with more than 50% magnesium in pellets, turnings, or ribbons)
Shipping Symbols:
Hazard Class: 4.1
ID No.: UN1869
Packing Group: III
Label: 4.1
Special Provisions (172.102): A1

Packaging Authorizations
a) **Exceptions:** 173.151
b) **Non-bulk Packaging:** 173.213
c) **Bulk Packaging:** 173.240

Quantity Limitations
a) **Passenger, Aircraft, or Railcar:** 25 kg
b) **Cargo Aircraft Only:** 100 kg

Vessel Stowage Requirements
a) **Vessel Stowage:** A
b) **Other:** 39

Section 15 - Regulatory Information

EPA Regulations:
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Magnesium powder is classified as a RCRA Hazardous Waste (40 CFR 261.23): Characteristic of Reactivity
Magnesium powder is listed as a CERCLA Hazardous Substance (40 CFR 302.4), as an Unlisted Hazardous Waste, Characteristic of Reactivity, 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:
Air Contaminant (29 CFR 1910.1000, Table Z-1): Not listed

Section 16 - Other Information

References: 73, 103, 136, 197

Prepared By................................ MJ Wurth, BS
Industrial Hygiene Review......... S Gilson, CIH
Medical Review........................... T Thoburn, MD, MPH

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Material Safety Data Sheet Collection

Potassium **MSDS No. 217**

Date of Preparation: 8/87 Revision: A, 3/97

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: Potassium
Chemical Formula: K
CAS Number: 7440-09-7
Synonym: Kalium
Derivation: By thermochemical distillation of potassium chloride with sodium or by electrolysis of molten salts. Potassium 40 is a naturally occurring radioactive isotope.
General Use: In the preparation of potassium peroxide, heat exchange alloys (see NaK); in the synthesis of inorganic potassium compounds; in organic syntheses involving condensation, dehalogenation, reduction and polymerization reactions; seeding of combustion gases in magnetohydrodynamic generators; as a compound of fertilizers; and the vaporized metal is used in turbines.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Potassium, 99.9+ % wt

Trace Impurities: Oxygen, carbon, hydrogen, alkali metals, aluminum, calcium, copper, boron and silicon, along with iron, nickel and chromium which are leached from container metals. High purity potassium potentially has transition metals and other alkali metals.

OSHA PEL	ACGIH TLV	NIOSH REL	DFG (Germany) MAK
None established	None established	None established	None established

Note! Although no occupational exposure limits have been established for potassium, this does not mean that this substance is not harmful. Follow safe work practices.

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Potassium exists as a soft, silvery-white, odorless solid. It reacts violently with air and water to form strongly alkaline potassium oxide and potassium hydroxide which will cause severe irritation and corrosive burns of any tissue they come in contact with. Potassium ions are essential for life, but in excessive concentrations may be harmful. It is spontaneously combustible and therefore a dangerous fire hazard. Reacts violently with water. It is a violent explosion hazard.

Wilson Risk Scale
R 3
I -
S 4
K 4

HMIS
H 3*
F 3
R 3
PPE†
*Chronic Effects
†Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, eye and skin contact
Target Organs: Eyes, skin, respiratory system
Acute Effects
Inhalation: Inhalation of dust or mist can irritate the eyes, nose, throat and lungs with sneezing, coughing and sore throat. Higher exposures may cause a potentially fatal buildup of fluid in the lungs (pulmonary edema).
Eye: Eye contact can cause severe burns leading to permanent damage.
Skin: Skin contact can cause severe burns leading to permanent damage. Prolonged exposure can lead to sores of the inner nose.
Ingestion: Significant esophageal or gastrointestinal tract irritation and/or burns could occur following ingestion.
Carcinogenicity: IARC, NTP, and OSHA do not list potassium as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: Respiratory disorders. Smoking may worsen respiratory conditions caused by potassium exposure.
Chronic Effects: Prolonged exposure may lead to sores of the inner nose and lung damage.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed. Medical observation is recommended for 24 to 72 hours after breathing overexposure, as pulmonary edema may be delayed.

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 or ophthalmologist 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. Consult a physician immediately.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. *Do not* induce vomiting. Consult a physician immediately.

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

Note to Physicians: Administer 100% humidified supplemental oxygen with assisted ventilation as required. If respiratory tract irritation or respiratory depression is evident, monitor arterial blood gases, chest x-ray and pulmonary function tests. Respiratory tract irritation, if severe, can progress to pulmonary edema which may be delayed in onset up to 24 to 72 hours after exposure. Treat dermal irritation or burns with standard topical therapy.

Section 5 - Fire-Fighting Measures

Genium

Flash Point: Flammable Solid

Autoignition Temperature: None reported.

LEL: None reported.

UEL: None reported.

Extinguishing Media: Use dry sand, dry chemical, soda ash or lime. *Do not* use water, foam, CO_2, or halogenated hydrocarbons.

Unusual Fire or Explosion Hazards: May ignite spontaneously if exposed to air or oxygen. May reignite after fire is extinguished. May ignite in presence of moisture. Violent reaction with water produces flammable hydrogen gas which can ignite from heat of reaction. Runoff to sewer may create fire or explosion hazard.

Hazardous Combustion Products: Potassium oxide.

Fire-Fighting Instructions: If feasible and without undue risk, move containers from fire hazard area. *Do not* release runoff from fire control methods to sewers or waterways. If tank, rail car or tank truck is involved in a fire, *isolate* for 800 meters (1/2 mile) in all directions.

Fire-Fighting Equipment: Because fire will produce irritating, corrosive and/or toxic gases, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Wear chemically protective clothing.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area), evacuate all unnecessary personnel and isolate and ventilate area. *Do not* touch or walk through spilled material. Keep away from water.

Small Spills: Isolate area for at least 50 to 100 meters. Cover spill with dry earth, dry sand or other noncombustible material.

Large Spills

Containment: Cover with a plastic sheet to minimize spreading or contact with rain. *Do not* release into sewers or waterways.

Cleanup: *Do not* clean up or dispose of, except under supervision of a specialist. Consider initial downwind evacuation for at least 250 meters (800 feet).

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

Section 7 - Handling and Storage

Handling Precautions: Avoid breathing vapors or contact with skin, eyes or clothing. Sources of ignition such as smoking, open flames and heat are prohibited. Use only nonsparking tools and equipment when opening and closing containers of potassium. Protect containers against physical damage.

Storage Requirements: Store in inert atmospheres, such as argon or nitrogen or under liquids that are oxygen-free, such as toluene, kerosene, or petroleum, or in glass capsules that have been filled under vacuum. Store in airtight containers to prevent oxidation. The corrosive nature of potassium will cause perforation of commercially available aluminum containers. Keep away from water and/or high temperatures. A detached, fire-resistant building is recommended for quantity storage.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Where feasible, enclose operations to prevent release into the work area. Use explosion-proof electrical equipment and filterings whenever potassium is used, handled, manufactured or stored.

Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations. 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 examinations to evaluate skin and respiratory conditions. Perform lung function tests. Communicate all information on the health and safety hazards of potassium to potentially exposed workers.

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 equipped with particulate (dust/fume/mist) filters. Check particulate filters every day before work for physical damage, such as rips or tears, and replace as needed. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA with a full facepiece operated in 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 to prevent skin contact. Wear protective eyeglasses or dust-proof goggles and face shield, 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: Soft, silvery-white metal
Odor Threshold: None
Vapor Pressure: 8 mm Hg at 810 °F (432 °C)
Formula Weight: 39.1
Specific Gravity (H_2O=1, at 4 °C): 0.86 at 68 °F (20 °C)
Water Solubility: Negligible
Other Solubilities: liquid ammonia, ethylenediamine, aniline, several metals, acid and mercury
Boiling Point: 1410 °F (765.5 °C)
Melting Point: 146 °F (63.2 °C)

Section 10 - Stability and Reactivity

Stability: Potassium is unstable. It may form reactive, explosive peroxides at room temperature even when stored under oil.

Polymerization: Hazardous polymerization cannot occur.

Chemical Incompatibilities: Reacts vigorously/violently with oxygen, water, acids, carbon monoxide, carbon tetrachloride, halogens, hydrogen, sulfur, hydrogen sulfide, and hydrogen halides. Reduces silicates, sulfates, nitrates, carbonates, phosphates, oxides and hydroxides of the heavy metals. Mixtures of potassium with metal halides are sensitive to mechanical shock and ensuing explosions range from very violent to weak. Mixtures of potassium with non-metal halides and non-metal oxides usually explode violently on impact.

Conditions to Avoid: When potassium has prolonged exposure to air and it comes into contact with an organic contaminant, i.e. mineral oil, an explosion will result.

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

Section 11- Toxicological Information

Toxicity Data:*

Acute Effects:

Mouse, intraperitoneal, LD_{50}: 700 mg/kg

* See NIOSH, *RTECS* (TS6460000), for additional toxicity data

Section 12 - Ecological Information

Ecotoxicity: Aquatic Toxicity: 80 ppm/24 hr/mosquito fish/TLm/ freshwater

Environmental Fate: Naturally occurring in Earth's crust 2.59% by weight. Present in seawater at a concentration of 3.8×10^{-5} ug/L. Present in ferromanganese nodules in the Pacific Ocean at 0.753 wt % and in the Atlantic Ocean at 0.56 wt %.

Section 13 - Disposal Considerations

Disposal: Safe disposal of potassium covers the separation of metal from adhering oxide by melting under xylene containing 1% of isopropanol; disposal of small metal residues by treatment with 1:1 ethyl acetate-hydrocarbon diluent mixtures; and disposal of 30 g blocks by dropping into a 2 meter deep hole in the ground containing 0.5 m of water. 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: Potassium
Shipping Symbols: —
Hazard Class: 4.3
ID No.: UN2257
Packing Group: I
Label: 4.3
Special Provisions (172.102): A19, A20, B27, B100, N6, N34, T15, T26

Packaging Authorizations
a) Exceptions: None
b) Non-bulk Packaging: 173.211
c) Bulk Packaging: 173.244

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 1 kg
b) Cargo Aircraft Only: 15 kg

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

Section 15 - Regulatory Information

EPA Regulations:

Classified as a RCRA Hazardous Waste (40 CFR 261.21, .22, .23): Characteristic of Ignitability, D001; Characteristic of Corrosivity, D002; Characteristic of Reactivity, D003

CERCLA Hazardous Substance (40 CFR 302.4) listed as, Unlisted Hazardous Waste: Characteristic of Ignitability, Corrosivity, and Reactivity, specific 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:

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

Section 16 - Other Information

References: 73, 103, 124, 136, 149, 190, 197, 209

Prepared By................................ M Sarjeant, BS/MJ Wurth, BS
Industrial Hygiene Review......... DJ Wilson, CIH
Medical Review........................... T Thoburn, MD, MPH

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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

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

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.

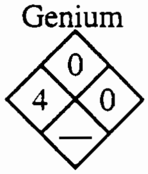
Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water and then wash exposed area with soap. For reddened or blistered skin, consult a physician.

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 ≤ 0.5 mg/m^3, use any chemical cartridge 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.

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. 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
I 4
S 1
K 0

Genium
0
2 0
-

HMIS
H 2
F 0
R 0
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/m^3

1987 IDLH Level
Vanadium Pentoxide Dust
or Fume (as V)
70 mg/m^3

1990-91 ACGIH TLV
Vanadium, as V_2O_5,
Respirable Dust and Fume
TWA: 0.05 mg/m^3

1988 NIOSH REL
Vanadium, as V_2O_5,
Respirable Dust and Fume
15-min Ceiling: 0.05 mg/m^3

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)

* 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/ft^3*	**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).

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/m³, 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/m³, 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 Collection

Sodium, Metal **MSDS No. 219**

Date of Preparation: 11/87 Revision: 3/97

Section 1 - Chemical Product and Company Identification

49

Product/Chemical Name: Sodium, Metal
Chemical Formula: Na
CAS Number: 7440-23-5
Synonyms: Natrium
Derivation: By electrolyzing a fused mixture of sodium chloride and calcium chloride
General Use: In the manufacture of tetraethyl and tetramethyl lead, in titanium reduction, sodium peroxide, sodium hydride, as a polymerization catalyst for synthetic rubber, as a lab reagent, as a coolant in nuclear reactors, in electric power cable, in nonglare lighting for highways, as radioactive forms in tracer studies and medicine, as a heat transfer agent in solar-powered electric generators.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Sodium, metal 99.9% wt
Impurities: Calcium and chlorides

OSHA PEL
None established

ACGIH TLV
None established

NIOSH REL
None established

IDLH Level
None established

DFG (Germany) MAK
None established

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Sodium is a solid lustrous metal. Moisture on skin surface, within cells, tissue, and mucous membranes will violently decompose sodium to sodium hydroxide, which causes burning of the skin, eyes, upper respiratory tract, and digestive tract. Heated sodium forms alkaline vapors which are caustic when inhaled. Although no occupational exposure limits have been determined, handle sodium metal with care and follow safe work practices. Violently decomposes on contact with water and may ignite spontaneously.

Wilson Risk Scale

R	3
I	-
S	4
K	4

HMIS

H	3*
F	2
R	3
PPE†	

*Chronic Effects
†Sec. 8

Potential Health Effects

Primary Entry Routes: Ingestion, respiration.
Target Organs: Eyes, skin, digestive and respiratory tract
Acute Effects
Inhalation: Causes irritation and severe burning of the respiratory tract with severe coughing and pain. After 72 hours may cause pulmonary edema (fluid in lungs), resulting in stridor (sounds of respiratory obstruction).
Eye: Causes severe burning and irritation of the cornea (surface tissue layer of the eye) and conjunctiva leading to irreversible damage and even permanent blindness.
Skin: Causes severe burning and irritation, with pain, redness, irritation or full thickness burns.
Ingestion: Causes severe burning and irritation, with associated drooling and vomiting. Ingestion may result in burns to the lips, tongue, oral mucous membrane, and upper airway.
Carcinogenicity: IARC, NTP, and OSHA do not list sodium as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: Respiratory and digestive tract disorders.
Chronic Effects: Chronic exposures can cause ulcers to form in the mouth and complications with respiratory and digestive tracts.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air, monitor for respiratory tract distress, 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 tepid water until transported to an emergency medical facility. Consult a physician or ophthalmologist immediately.
Skin Contact: *Quickly* remove contaminated clothing. Wash exposed area extremely thoroughlywith 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 rinse residual sodium around the mouth with flooding amounts of water. *Do not* induce vomiting. Contact physician immediately.

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

Note to Physicians: For oral exposure, the use of diluents is controversial, neutralization is contraindicated, and activated charcoal is not indicated. Perform esophagoscopy 12 to 24 hours after ingestion to determine severity where history indicates a definite ingestion of a caustic substance or where stridor, dysphagia or drooling are present. During esophagoscopy take care to avoid perforation of severely burned esophageal tissue. Treat dermal contamination with standard topical therapy, or if indicated for cases of hypersensitivity, treat with corticosteroids or antihistamines.

Special Precautions/Procedures: Use caution in the administration of steroids for burns and antibiotic for infection.

Section 5 - Fire-Fighting Measures

Flash Point: Flammable solid

Autoignition Temperature: 239°F (115°C)

LEL: None reported.

UEL: None reported.

Extinguishing Media: Use dry graphite, soda ash, powdered sodium chloride or appropriate dry powder. *Do not* use water, carbon dioxide, or halogenated extinguishing agents.

Unusual Fire or Explosion Hazards: Heated sodium is spontaneously flammable in air. Dangerous explosion hazard when exposed to moisture in any form.

Hazardous Combustion Products: Including sodium oxides (Na_2O, Na_2O_2) which can react with moisture or steam to produce heat, sodium hydroxide, and flammable hydrogen gas.

Fire-Fighting Instructions: If feasible and without undue risk, move containers from fire hazard area. Otherwise, cool fire-exposed containers until well after fire is extinguished. Do not release runoff from fire control methods to sewers or waterways. *Do not* get water inside containers, cool containers with flooding quantities of water until well after fire is out, and withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.

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. Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Structural firefighters' protective clothing will only provide limited protection.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, evacuate all unnecessary personnel, remove heat and ignition sources, isolate and ventilate area, deny entry, stay upwind. Shut off ignition source. *Do not* use flares in the area. *Do not* touch or walk through spilled material; stop leak if you can do it without risk. *Do not* put water on spilled materials or inside container

Small Spills: For dry spills, place into clean dry container with clean dry shovel, cover, and move from spill area. For wet spills, take up with sand or other noncombustible absorbent and material and place into container for later disposal.

Large Spills

Containment: For large spills, dike far ahead of liquid spill for later disposal. *Do not* release into sewers or waterways.

Cleanup: Cover spill with plastic sheet or tarp to minimize spreading. Avoid dust generation. *Do not* dry sweep. Absorb spilled sodium dry, cover remainder with kerosene, paraffin oil or dry sand, eliminate last traces with methylated spirit.

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

Section 7 - Handling and Storage

Handling Precautions: Label as a flammable solid.

Storage Requirements: Place in hermetically-sealed steel drums, tin cans, and tank cars. *Do not* stack in tiers. Keep away from water, especially sprinkler systems. Keep submerged in oxygen free liquids, eg., kerosene or naphtha. Store large quantities in a separate fire-resistive building. Avoid mechanical injury of containers, exposure to heat, and wet conditions. Automatically transfer sodium from drums or other storage containers to process containers.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Enclose operations and /or provide local exhaust ventilation at the site of chemical release. Isolate operation to reduce exposure.

Ventilation: Provide general or 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)

Administrative Controls: Consider preplacement and periodic medical exams with emphasis on the respiratory and digestive tracts. Perform lung function tests. Stress good work practices to reduce hazardous exposures, removing and exchanging contaminated clothing promptly, monitor for exposure to sodium and sodium particulate levels, and provide worker training the use and handling of sodium.

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. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. 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 and faceshield, 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: Light, silvery-white metal, wax-like at room temperature, lustrous when freshly cut; odorless

Vapor Pressure: 1.2 mm Hg at 752 °F (400 °C)

Formula Weight: 22.98977 g/mol

Density (H_2O=1, at 4 °C): 0.968 g/cm^3

Water Solubility: Violently decomposes.

Other Solubilities: Insoluble in ether or benzene, dissolves in liquid ammonia and mercury

Boiling Point: 1618.5 °F (881.4 °C)

Melting Point: 208.1 °F (97.82 °C)

Refractive Index: 4.22

Heat Capacity of Solid: 0.292 cal/g degree

Heat of Fusion: 27.05 cal/g

Section 10 - Stability and Reactivity

Stability: Sodium is unstable at room temperature in closed containers under normal storage and handling conditions. It oxidizes readily with air.

Polymerization: Hazardous polymerization can not occur with sodium.

Chemical Incompatibilities: Sodium metal reacts vigorously or explosively with oxidizing agents. The following materials may cause an explosive reaction: water; 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; and sulfur dioxide.

Conditions to Avoid: Avoid wet conditions, heat, air, and exposure to oxide and halide compounds, eg., aluminum bromide, antimony triiodide, etc.

Hazardous Decomposition Products: Thermal oxidative decomposition of sodium can produce sodium oxides [including sodium monoxide (Na_2O), sodium dioxide (NaO_2), and sodium peroxide (Na_2O_2)].

Section 11 - Toxicological Information

Toxicity Data:*

Acute Oral Effects:

Mouse, intraperitoneal, LD_{50}: 4 g/kg

* See NIOSH, *RTECS* (VY0686000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Sodium is dangerous to aquatic life in high concentrations and may be dangerous if it enters intakes.

Environmental Fate: Data not found.

Section 13 - Disposal Considerations

Disposal: Destroy scraps by reaction with *n*-butyl alcohol. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Container: Store empty sodium drums in storage area until disposed.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Sodium

Shipping Symbols: –

Hazard Class: 4.3

ID No.: UN1428

Packing Group: I

Label: DANGEROUS WHEN WET

Special Provisions (172.102): A7, A8, A19, A20, B9, B48, B68, N34, T15, T29, T46

Packaging Authorizations
- a) **Exceptions:** None
- b) **Non-bulk Packaging:** 173.211
- c) **Bulk Packaging:** 173.244

Quantity Limitations
- a) **Passenger, Aircraft, or Rail car:** 1 kg
- b) **Cargo Aircraft Only:** 15 kg

Vessel Stowage Requirements
- a) **Vessel Stowage:** D
- b) **Other:** –

Section 15 - Regulatory Information

EPA Regulations:

RCRA Hazardous Waste (40 CFR 261.33): Not listed
Classified as a RCRA Hazardous Waste (40 CFR 261.24, .23): Characteristic of Ignitability and Reactivity
CERCLA listed specific per CWA, Sec. 311 (b)(4)
CERCLA Reportable Quantity (RQ), 10 lb (4.54kg)
SARA Toxic Chemical (40 CFR 372.65): Not listed
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed

OSHA Regulations:

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

Section 16 - Other Information

References: 73, 103, 124, 136, 149, 190, 197, 209

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Industrial Hygiene Review .... DJ Wilson, CIH
Medical Review .... W Boucher, 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

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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.

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

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.

HMIS		**Not Found**	
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 *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.	Ca 100	IDLH* Level: 20 mg/m^3 (Soluble Compounds) **OSHA PEL (Skin**)** 8-Hr TWA:*** 0.1 mg/m^3 **ACGIH TLV, 1987-88** TLV-TWA:*** 0.1 mg/m^3 **Toxicity Data****** Man, Oral, TD$_{Lo}$: 5.714 mg/kg

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.

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. PJI

Prepared by PJ Igoe, BS

Industrial Hygiene Review: DJ Wilson, CIH

Medical Review: MJ Hardies, MD

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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

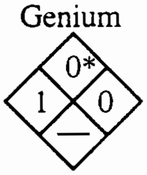
Potential Health Effects

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.

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.

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 $\leq$ 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 $\leq$ 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 $\leq$ 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.

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

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 Sheets Collection

Acetone

MSDS No. 300

Issued: 11/77
Revision: F, 9/92

Section 1 - Chemical Product and Company Identification

Material Name .... Acetone
Chemical Formula .... CH_3COCH_3
CAS No. 67-64-1

Other Designations: AI3-01238, Chevron acetone, dimethylformaldehyde, dimethylketal, dimethyl ketone, ß-ketopropane, methyl ketone, propanone, 2-propanone, pyroacetic acid, pyroacetic ether.

Derivation: 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.

Use: 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, airplane 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.

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

Section 2 - Composition / Information on Ingredients

Acetone: 99.5%, 0.5% Water

1991 OSHA PELs *
8-hr TWA: 750 ppm (1,800 mg/m^3)
15-min STEL: 1,000 ppm (2,400 mg/m^3)

1992-93 ACGIH TLVs
TWA: 750 ppm (1,780 mg/m^3)
STEL: 1,000 ppm (2,380 mg/m^3)

1990 NIOSH REL
TWA: 250 ppm (590 mg/m^3)

1990 IDLH Level
20,000 ppm

1990 DFG (Germany) MAK
1,000 ppm (2,400 mg/m^3)
Category IV: Substances eliciting very weak effects (MAK > 500 mL/m^3)
Peak: 2,000 ppm, 60 min, momentary value,† 3 peaks/shift

* 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.

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Colorless, highly volatile liquid; sweetish odor. 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.

Wilson Risk Scale	
R	1
I	1
S	1*
K	3

* Slight skin absorption

HMIS	
H	1
F	3
R	0
PPE†	

†Sec. 8

Potential Health Effects

Carcinogenicity: IARC, NTP, and OSHA 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. Exposure to less than 1,000 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 (above 2,000 ppm). Concentrations above 12,000 ppm cause loss of consciousness.

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:

Eye: Direct eye contact by liquid acetone may produce painful burning and stinging; watering of eyes; conjunctival inflammation; and corneal injury.

Skin: Skin contact produces a cold feeling, dryness, and mild irritation.

Inhalation: 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.

Ingestion: Human systemic effects by ingestion include gastrointestinal irritation, kidney damage (often indicated by albumin and red and white blood cells in urine), liver damage (indicated by high levels of urobilin and early appearance of bilirubin),

Acute Effects (cont.):
coma, metabolic changes, and systemic effects described for inhalation.

Chronic effects: Cases of chronic poisoning resulting from prolonged exposure to low concentrations of acetone are rare. Workers exposed to 1,000 ppm, 3 hr per day for 7-15 yr, 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.

Section 4 - First Aid Measures

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.

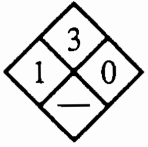
After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: In symptomatic patients, monitor serum and urine acetone levels, 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 hr). Patients may develop hyperglycemia and ketosis mimicking acute diabetic coma. The hyperglycemia may persist for several days following acute exposure.

Section 5 - Fire Fighting Measures

Flash Point	0°F (-18°C), CC
Autoignition Temperature	869°F (465°C)
LEL	2.6% v/v
UEL	12.8% v/v

NFPA



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. A vapor explosion hazard may exist indoors, outdoors, or, in sewers.

Fire-Fighting Instructions: 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. 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 limited protection. For massive cargo fires, use unmanned hose holder or monitor nozzles.

Section 6 - Accidental Release Measures

Spill / Leak Procedures: 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.

Small Spills: For small spills, take up with sand or other noncombustible absorbent material and using nonsparking tools, place into containers for later disposal.

Large Spills: For large spills, dike far ahead of liquid spill for later disposal. Do not release into sewers or waterways. Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

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.

Handling Precautions: Use nonsparking tools to open containers. Keep dry chemical or CO_2 extinguishers on hand in case of fire.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: 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.

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)

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.

Protective Clothing/Equipment: 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. 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 concentrations < 1,000 ppm, wear any chemical cartridge respirator with organic vapor cartridge(s) and wear eye protection to avoid irritation or damage. For concentrations < 6,250 ppm, wear any supplied-air respirator operated in a continuous-flow mode. For concentrations < 12,500 ppm, wear any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. For concentrations < 20,000 ppm, wear any supplied-air respirator that has a full facepiece and is operated 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.

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

Contaminated Equipment: Separate contaminated work clothes form 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
Color	Colorless
Odor	Sweet
Odor Threshold	47.5 mg/m^3 to 1,613.9 mg/m^3 *
Boiling Point	133.2°F (56.2°C) at 760 mm Hg
Freezing Point	-139.6°F (-95.35°C)
Refractive Index	1.3588 @ 20°C
Water Solubility	Soluble
Molecular Weight	58.08
Other Solubilities	Alcohol, benzene, dimethyl formamide, chloroform, ether, and most oils
Specific Gravity	0.7889 @ 20°C /4°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/m^3, 0.075 lb/ft^3 1.48 kg/m^3· .093 lb/ft^3

* Odor thresholds recorded as a range from the lowest to the highest concentration.

Section 10 - Stability and Reactivity

Stability: Acetone is stable at room temperature in closed containers under normal storage and handling conditions.

Polymerization: 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 + alkalis, 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 11- Toxicological Information

Toxicity Data:*

Eye Effects:
Human, eye: 500 ppm

Acute Oral Effects:
Rat, oral, LD_{50}: 5800 mg/kg altered sleep time and produced tremors.

Acute Inhalation Effects:
Human, inhalation, TC_{Lo}: 500 ppm produced olfaction effects, conjunctival irritation, and other changes involving the lungs, thorax, or respiration.
Mammal, inhalation, TC_{Lo}: 31,500 $\mu g/m^3$/24 hr administered to pregnant female from the 1^{st} to 13^{th} day of gestation produced effects on fertility (post-implantation mortality).

* See NIOSH, *RTECS* (AL3150000), for additional irritation, mutation, reproductive, and toxicity data.

Section 12 - Ecological Information

Ecotoxicity: LC_{50} *Salmo gairdneri* (rainbow trout): 5,540 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.

Section 13 - Disposal Considerations

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.

Section 14 - Transport Information

Transportation Data (49 CFR 172.101):

DOT Shipping Name...... Acetone
DOT Hazard Class......... 3
ID No............................ UN1090
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..............................—

Section 15 - Regulatory Information

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), 5,000 lb (2,270 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 16 - Other Information

***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.

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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

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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‡
4
2 0
—

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

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. 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
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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/m^3)
15-min STEL: 450 ppm (2450 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
15-min Ceiling: 350 ppm (1900 mg/m^3)

1991-92 ACGIH TLVs
TWA: 350 ppm (1910 mg/m^3)
STEL: 450 ppm (2460 mg/m^3)

1990 DFG (Germany) MAKs
TWA: 200 ppm (1080 mg/m^3)
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/m^3/10 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.

Continue on next page

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/7 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. 366
Chlorobenzene

Issued: 11/82 Revision: B, 11/90

Section 1. Material Identification

33

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.

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.

R	1
I	3
S	2
K	3

NFPA

HMIS

H	2
F	3
R	0
PPG*	

* Sec. 8

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.

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

DDT (Dichlorodiphenyltrichloroethane)
MSDS No. 155
Date of Preparation: 10/93

Section 1 - Chemical Product and Company Identification 42

Product/Chemical Name: .... DDT (Dichlorodiphenyltrichloroethane)
Chemical Formula: .... $(ClC_6H_4)_2CHCCl_3$
CAS No.:................................ 50-29-3

Synonyms: Agritan; 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane; chlorophenothan; Citox; dichlorodiphenyltrichloroethane; Dicophane; diphenyltrichloroethane; Genitox; Kopsol; NCI-C00464; Neocid; Pentech; trichlorobis (4-chlorophenyl) ethane; 1,1'-(2,2,2-trichloroethylidene)bis(4-chlorobenzene), Zerdane.

Derivation: Prepared by condensing chloral or chloral hydrate with chlorobenzene in presence of sulfuric acid.

General Use: One of the most widely used contact insecticides from 1945 until its ban in 1972. Although banned in the U.S. (except for such uses as emergency health situations and for controlling body lice), it is still widely used in the tropics for control of vector-carrying diseases such as malaria, yellow fever, dengue, filariasis, louse-borne typhus, and louse-borne relapsing fever.

Section 2 - Composition / Information on Ingredients

DDT: *p'p'*DDT 70% wt + *o'p'*DDT 30% wt (technical grade)
Trace Impurities: DDD, DDE

OSHA PELs
8-hr TWA: 1 mg/m^3 (skin)

ACGIH TLVs
TWA: 1 mg/m^3

NIOSH REL
10-hr TWA: 0.5 mg/m^3
Ca*: (Limit of quantitation: 0.1 mg/m^3)

IDLH Level
Ca*

DFG (Germany) MAK (skin)
TWA: 1 mg/m^3 (total dust)
Category III: Substances with systemic effects
Onset of effect: > 2 hr.
Peak Exposure Limit: 10 mg/m^3, 30 min. average value, 1/shift

* Ca = Carcinogen

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

DDT is a white to gray, crystalline solid. Although it has been banned in the U.S. because of its persistence in the environment and potential for bioaccumulation, DDT has not produced toxicity in workers who either manufactured or used it (even over many years). However, this lack of toxicity is based on inhalation and skin absorption. If DDT is ingested, especially in large amounts, central nervous system effects will occur with possible liver damage. DDT is considered a confirmed animal carcinogen and a suspected human carcinogen.

Wilson Risk Scale
R 1
I 3
S 1*
K 2
*Skin absorption

HMIS
H 2†
F 2
R 0
†chronic effects
PPE‡
‡Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, ingestion, skin contact.
Target Organs: Central nervous system, liver, skin, peripheral nervous system.
Acute Effects
Inhalation: Inhalation does not appear to cause toxicity beyond that of minor mechanical irritation.
Eye: Exposure to 423 mg/m^3/1 hr/day for 6 days caused eye irritation.
Skin: Skin absorption may occur from some DDT solutions, but degree of absorption will depend on the solvent involved. Aqueous solutions and the powder or crystals are not easily absorbed.
Ingestion: DDT can cause a variety of central nervous system effects if ingested. Large doses generally result in vomiting, while smaller doses cause symptoms within 2 to 3 hr post-ingestion. Symptoms include tingling of the lips, tongue, and face; malaise; headache; sore throat; fatigue; tremors of the head, neck, and eyelids; apprehension; ataxia; and confusion. Convulsions and paralysis of the hands is possible in severe exposures (if vomiting does not occur). Vital signs are usually normal, but in severe poisonings, the pulse may be irregular and abnormally slow. Based on animal studies, it is expected that ventricular fibrillation and sudden death can occur at any time during acute poisoning. Recovery from acute poisoning generally occurs within 24 hr except in the most serious cases.

Carcinogenicity: DDT is considered a suspected human carcinogen by several governmental agencies. IARC-2B (possibly carcinogenic to humans, limited evidence in humans in the absence of sufficient evidence in experimental animals), NTP-2 (reasonably anticipated to be a carcinogen: limited human evidence or sufficient animal evidence), EPA-B2 (sufficient animal evidence; inadequate human evidence), and NIOSH-X (carcinogen defined without further categorization)

Medical Conditions Aggravated by Long-Term Exposure: Possibly, disorders of the central nervous system and liver.

Chronic Effects: There are conflicting reports on whether or not DDT produces chronic effects in humans. Although it is well established that chronic exposure in experimental animals produces effects including liver damage, CNS degeneration, dermatitis, weakness, convulsions, coma, and death, these effects are not confirmed in humans. Liver cancer is confirmed in animals, but has not been documented in humans. These conflicting reports appear due to the lack of documented chronic toxicity in workers and data showing that DDT and its metabolites are retained in the body fat for long time periods, thus providing a basis for the *possibility* of chronic toxicity.

Other: Solvents such as kerosine are added to DDT as a vehicle and, depending on the type involved, may be more toxic than DDT itself.

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 any loose material and 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.

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. *Do not* induce vomiting. Gastric lavage should be performed promptly.

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

Notes to Physicians: Effects may be delayed; keep under observation.

Special Precautions/Procedures: Amobarbital or pentobarbital is recommended for the relief of central neurological manifestations; tribromoethanol and paraldehyde are recommended for allaying prolonged convulsions.

Section 5 - Fire-Fighting Measures

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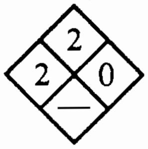

Flash Point: DDT itself is noncombustible but is dissolved in a variety of solvents. The average quoted Flash Point is 162 °F (72.2 °C) although the specific vehicle is not identified.

Flash Point Method: CC

Autoignition Temperature: None reported

LEL: None reported

UEL: None reported

Flammability Classification: Class IIIA Combustible Liquid (varies depending on vehicle)

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: Container may explode in heat of fire.

Hazardous Combustion Products: Chloride fumes and carbon oxide gases.

Fire-Fighting Instructions: Do not release runoff from fire control methods to sewers or waterways. Fight fire from maximum distance. Stay away from ends of tanks.

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 fire fighters' protective clothing is *not* effective.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources. Cleanup personnel should protect against contamination.

Small Spills: For dry spills, carefully scoop up material or vacuum (with an approved filter). Damp mop any residue. For small solution spills, take up with earth, sand, vermiculite, or other absorbent material and place in suitable containers for disposal.

Large Spills

Containment: Dike far ahead of liquid spill for later reclamation or disposal. Do not release into sewers or waterways.

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

Section 7 - Handling and Storage

Handling Precautions: Use non-sparking tools to open containers. Keep dry chemical extinguishers on hand in case of fire.

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles (Sec. 10). *Do not* store in aluminum or iron containers.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: To prevent static sparks, electrically ground and bond all equipment used with and around DDT.

Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below 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 liver and central nervous system.

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 a SCBA with a full facepiece and operated in pressure demand or other positive-pressure mode, or any supplied-air respirator with a full facepiece and operated in pressure demand or other positive-pressure mode with an auxiliary SCBA. 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 made of butyl rubber 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). 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 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: White to gray crystals or powder which is odorless or has a slight aromatic odor.

Odor Threshold: 5.0725 mg/m^3

Vapor Pressure: 5.5 x 10^{-6} mm Hg at 68 °F (20 °C)

Formula Weight: 354.48

Specific Gravity (H_2O=1, at 4 °C): 0.98 to 0.99

Water Solubility : 0.0012 ppm

Other Solubilities (g DDT/100 mL): acetone 58, 95% alcohol 2, benzene 78, benzyl benzoate 42, carbon tetrachloride 45, chlorobenzene 74, cyclohexanone 116, dibutyl phthalate 33, o-dichlorobenzene 68, dichlorodifluoromethane 2, dioxane 100, ethyl ether 28, gasoline 10, isopropanol 3, kerosine 8 to 10, methylated naphthalenes 40 to 60, mineral oil 5, morpholine 75, peanut oil 11, pine oil 0 to 16, tetralin 61, tributyl phosphate 50, and xylene 60.

Boiling Point: 365 °F (185 °C)

Melting Point: 227 °F (108.3 °C)

Section 10 - Stability and Reactivity

Stability: DDT is stable at room temperature in closed containers under normal storage and handling conditions. It biodegrades very slowly.

Polymerization: Hazardous polymerization does not occur.

Chemical Incompatibilities: Strong oxidizers, alkaline materials, iron and aluminum salts.

Conditions to Avoid: Exposure to heat, ignition sources, and incompatibles.

Hazardous Decomposition Products: Thermal oxidative decomposition of DDT can produce carbon dioxide.

Section 11- Toxicological Information

Toxicity Data:*

Eye Effects: None reported.

Skin Effects: None reported.

Acute Oral Effects:
Human, oral, LD_{Lo}: 500 mg/kg caused convulsions, cardiac arrhythmias, and respiratory changes.
Rat, oral, LD_{50}: 87 mg/kg; details not reported

Carcinogenicity: Rat, oral, TD_{Lo}: 1225 mg/kg given for 7 continuous weeks caused liver tumors.

Mutagenicity: *E. coli*: 15 μmol/L caused DNA damage.

Teratogenicity: Rat, oral, TD_{Lo}: 112 mg/kg given to a 56 day old male caused paternal effects (spermatogenesis, testes, epididymis, sperm duct).

* See NIOSH, *RTECS* (KJ3325000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Glass shrimp (*Palaemonestes kadiakensis*), LC_{50} = 2.3 mcg/L/96 hr at 69.8 °F (21 °C); Japanese quail, 2 month old male, (*Coturnix japonica*), LD_{50} = 841 mg/kg; bluegill (*Lepomis macrochirus*), LC_{50} = 28.7 mcg/L/36 hr.

Environmental Degradation: In water, DDT will adsorb strongly to sediments, significantly bioconcentrate in fish, and will be subject to considerable evaporation with an estimated half-life of several hr to almost 50 hr from certain waters. It may biodegrade when high concentrations of required microbes (*Escherichia, Hydrogenomonas*, and *Saccharomyces*) are present. On land, DDT will adsorb strongly and should not appreciably leach to groundwater. It may evaporate (half-life of 100 days) and is subject to photooxidation from soil. DDT may significantly biodegrade in flooded soils or under anaerobic conditions provided high populations of the required microbes are present. Half-life ranges from 2 to >15 yr. In the air, DDT is subject to direct photooxidation and reaction with photochemically produced hydroxyl radicals (est. half-life = 2 days). Wet and dry deposition are significant mechanisms for removal from air.

Section 13 - Disposal Considerations

Disposal: DDT is a good candidate for rotary kiln or liquid injection incineration (furnace with afterburner and alkali scrubber). 60 to 80% removal of DDT from contaminated soils has been achieved in 10 min. by super critical-carbon dioxide extraction. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Container Cleaning and Disposal: Triple rinse containers. Containers in good condition should be returned to the manufacturer and those that are not reusable should be punctured and transported to a scrap metal facility for recycling, disposal, or burial in a designated landfill.

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:
RCRA Hazardous Waste Number (40 CFR 261.33): U061
Listed as a RCRA Hazardous Waste Classification (40 CFR 261.33)
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 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, 101, 103, 124, 126, 127, 132, 133, 136, 139, 148, 153, 167, 168, 169, 176, 180, 183

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Industrial Hygiene Review .... PA Roy, MPH, CIH
Medical Review .... T Thoburn, MD, MPH

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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.

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.

R 1
I 4
S 2*
K 4
*Skin absorption

NFPA
3
2 0
-

HMIS
H 3
F 3
R 0
PPG†
† Sec. 8

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.

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. 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/m^3

1987 IDLH Level
1700 ppm

1989-90 ACGIH
TLV-STEL (ceiling): 50 ppm, 301 mg/m^3

1988 NIOSH REL
None established

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

* 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/m^3; o-dichlorobenzene is irritating at 150 mg/m^3. 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^-).

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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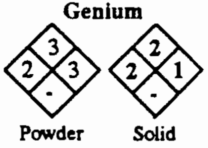
Material Safety Data Sheets Collection:

Sheet No. 758
Iron

Issued: 7/91

Section 1. Material Identification

34



R	1
I	2
S	1
K	1

HMIS	
H	2
F	2
R	1
PPG*	

* Sec. 8

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.

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.

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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Material Safety Data Sheets Collection:

Sheet No. 723
Nickel Metal

Issued: 8/90

Section 1. Material Identification

32

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 0
I 3
S 2
K 1

NFPA	Genium
4	1
2 0	2 0
	-
catalyst	metal
HMIS	HMIS
H 2	H 2
F 4	F 1
R 0	R 0
PPG†	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	1989-90 ACGIH TLV	1988 NIOSH REL	1985-86 Toxicity Data*
8-hr TWA: 1 mg/m^3	TLV-TWA: 1 mg/m^3	0.015 mg/m^3	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

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. 789
Cyanide

Issued: 11/91

Section 1. Material Identification 36

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.

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.

R 1
I 4
S 2
K 1

Genium

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

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)

1990 IDLH Level
50 mg/m³

1991-92 ACGIH TLV (Skin)
Ceiling: 10 ppm, 11 mg/m³, as hydrogen cyanide (gas)

1990 NIOSH REL (Skin)
STEL: 4.7 ppm, 5 mg/m³ as hydrogen cyanide (gas)

1990 DFG (Germany) MAK (*Danger of cutaneous absorption*)
TWA: 10 ppm, 11mg/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

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	**IMO Shipping Name:** Cyanides, inorganic, n.o.s.
DOT Hazard Class: Poison B	**IMO Hazard Class:** 6.1
ID No.: UN1588	**ID No.:** UN1588
DOT Label: Poison	**IMO Label:** Poison
DOT Packaging Exceptions: 173.364	**IMDG Packaging Group:** I/II; Stow 'away from' acids
DOT Packaging Requirements: 173.370	

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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Material Safety Data Sheets Collection:

Sheet No. 517
Pentachlorophenol

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

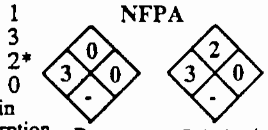
Section 1. Material Identification

33

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 (preharvest 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/m^3

1987 IDLH Level
150 mg/m^3

1990-91 ACGIH TLV
TWA (skin): 0.5 mg/m^3

1988 NIOSH REL
None established

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/m^3 inhaled affects behavior (excitement; muscle contraction or spasticity) and respiration (shortness of breath)

* 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/m^3 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

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 Shipping Name:** Chlorophenols, solid
IMO Hazard Class: 6.1	**IMO Hazard Class:** 6.1
ID No.: UN2021	**ID No.:** UN2020
IMO Label: St. Andrews Cross	**IMO Label:** St. Andrews Cross
IMDG Packaging Group: III	**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. 683
Polychlorinated Biphenyls (PCBs)

Issued: 11/88 Revision: A, 9/92

Section 1. Material Identification

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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.

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

R 1
I 4
S 3*
K 1
* Skin absorption

NFPA
1
2 0
–

HMIS
H 2‡
F 1
R 0
PPE†
† Sec. 8
‡ Chronic Effects

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/m^3
8-hr TWA (Chlorodiphenyl, 54% chlorine): 0.5 mg/m^3

1990 DFG (Germany) MAK, Danger of Cutaneous Absorption
TWA (Chlorodiphenyl, 42% chlorine): 0.1 ppm (1 mg/m^3)
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/m^3)
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/m^3
TWA (Chlorodiphenyl, 54% chlorine): 0.001 mg/m^3

1992-93 ACGIH TLVs, Skin *
TWA (Chlorodiphenyl, 42% chlorine): 1 mg/m^3
TWA (Chlorodiphenyl, 54% chlorine): 0.5 mg/m^3

* 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.

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 Sheet Collection

DDD **MSDS No. 939**

Date of Preparation: 12/94

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: DDD
Chemical Formula: $(ClC_6H_4)_2CHCHCl_2$
CAS No.: 72-54-8
Synonyms: benzene, 1,1'-(2,2-dichloroethylidene) bis (4-chlorobenzene); 1,1-dichloro-2,2-bis (*p*-chlorophenyl) ethane; dichlorodiphenyldichloroethane; Dilene; Rothane; TDE; tetrachlorodiphenylethane
Derivation: DDD is no longer produced or sold commercially in the USA. Prepared by chlorination of ethanol and subsequent condensation with chlorobenzene. DDD also occurs naturally as a degradation product of DDT.
General Use: Formerly used as a pesticide (dusts, emulsions, and wettable powders) for control of leaf rollers and other insects.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Ingredient, ca >90 % wt (*p, p'* isomer)
Trace Impurities: ≤ 10% *o, p'* isomer

OSHA PEL	NIOSH REL	DFG (Germany) MAK
None established	None established	None established

ACGIH TLV
None established

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

DDD exists as odorless, colorless crystals. It is irritating to the skin, eyes, and respiratory tract. Systemic toxicity is similar to that caused by DDT (*Genium MSDS* #155), but to a slightly lesser extent. The central nervous system and liver appear to be most affected. Skin absorption can occur. Although combustible, DDD does not burn readily. Banned from US production because of its ability to bioconcentrate and its persistency in the environment.

Potential Health Effects

Primary Entry Routes: Inhalation, ingestion, skin absorption.
Target Organs: Eyes, skin, respiratory tract, central nervous system, liver.
Acute Effects
Inhalation: Symptoms include irritation of the respiratory tract, nausea, vomiting, and excitement followed by lethargy (general tiredness). Exposure to DDD appears to result in less severe symptoms than exposure to its higher analogue, DDT.
Eye: Contact causes minor irritation.
Skin: Contact causes minor irritation. Absorption can cause systemic effects.
Ingestion: Ingestion causes CNS effects (see inhalation). The estimated fatal dose is 5g/kg.
Medical Conditions Aggravated by Long-Term Exposure: Liver disorders.
Chronic Effects: Repeated exposure can lead to liver damage and atrophy (deterioration) of the adrenal cortex.
Carcinogenicity: Listed by IARC (Class 2B carcinogen, possibly carcinogenic in humans) and the EPA (Class B2 carcinogen, inadequate human and adequate animal data) as a carcinogen. Although the NTP reports DDD to have produced cancer in animals, it has only given a formal designation to DDT.
Other: In general, exposure to organochlorine pesticides have been indicated in spontaneous abortions and premature delivery.

Wilson Risk Scale
R 1
I –
S 2*
K 1
*Skin absorption

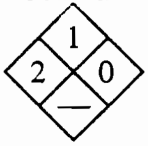
HMIS
H 2*
F 1
R 0
* Chronic effects
PPE†
†Sec. 8

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. Consult an ophthalmologist if pain or irritation persist.
Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water followed by a soap and water wash. Consult a physician if pain or irritation persist.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Vomiting may be spontaneous.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Treatment is symptomatic and supportive.

Section 5 - Fire-Fighting Measures

Genium



Flash Point: None reported. DDD is combustible, but does not ignite readily.
Autoignition Temperature: None reported.
LEL: None reported.
UEL: None reported.
Flammability Classification: Combustible solid
Extinguishing Media: Use dry chemical, carbon dioxide, regular foam, or water spray.
Unusual Fire or Explosion Hazards: None reported.
Hazardous Combustion Products: Include chlorine and hydrogen chloride 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.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind.
Small Spills: Carefully scoop or vacuum (with appropriate filter) and place in suitable container for disposal.
Large Spills: Flush spill with water to containment area. Absorb with activated carbon. Do not release into sewers or waterways.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Wear appropriate PPE to prevent inhalation, eye contact, and skin absorption.
Storage Requirements: Store in a cool, dry, well-ventilated area away from alkalis.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Since DDD is no longer produced in the USA, engineering controls are not normally applicable. However, when DDD is encountered through analysis and disposal procedures, it is important that processes are enclosed to prevent dispersion of DDD dusts or contaminated (DDD) soil through the work area.
Ventilation: Provide general or 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)
Administrative Controls: Consider preplacement and periodic medical exams of all workers potentially exposed to DDD. Emphasis should be placed on liver function.
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. 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.
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 or plan for disposal. Remove DDD from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after potential exposure to DDD, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Solid
Appearance and Odor: Odorless, colorless crystals
Vapor Pressure: 10.2×10^{-7} mm Hg at 86 °F (30 °C)
Formula Weight: 320.05
Density (H_2O=1, at 4 °C): 1.385 g/cm^3
Water Solubility: 0.005 ppm
Other Solubilities: Soluble in organic solvents
Boiling Point: 379.4 °F (193 °C) at 1 mm Hg
Melting Point: 228.2 to 230 °F (109 to 110 °C)
Octanol/Water Partition Coefficient: log Kow = 6.02

Section 10 - Stability and Reactivity

Stability: DDD is stable at room temperature in closed containers under normal storage and handling conditions.
Polymerization: Hazardous polymerization does not occur.
Chemical Incompatibilities: Alkalis.
Conditions to Avoid: Exposure to ignition sources and alkalis.
Hazardous Decomposition Products: Thermal oxidative decomposition of DDD can produce chlorine gas.

Section 11- Toxicological Information

Toxicity Data:*

Acute Dermal Effects:
Rabbit, skin, LD_{50}: 1200 mg/kg caused primary irritation, excitement and convulsions or effect on seizure threshold, and death in 50% of test animals.

Mutagenicity:
Mouse embryo: 28,400 nmol/L caused oncogenic transformation.

Acute Oral Effects:
Rat, oral, LD_{50}: 113 mg/kg

Tumorigenicity:
Rat, oral: 54 g/kg/78 continuous weeks caused thyroid tumors.

* See NIOSH, *RTECS* (KI0700000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Japanese quail, $LC_{50} = 3165$ ppm ; mallard duck, $LC_{50} = 4814$ ppm; rainbow trout, $LC_{50} = 70$ µg/L/96 hr.
Environmental Transport: If released to soil, DDD will absorb strongly with very little leaching to groundwater. In water, DDD will absorb strongly to sediment and bioconcentrate in aquatic animals. Hydrolysis is not appreciable; est. half-life is 570 days (pH 9) and 190 days (pH 5). Evaporation will be slow; est. half-life from a model river 1 m deep, flowing 1 m/sec with a wind velocity of 3 m/sec is 1.82 days.
Environmental Degradation: Biodegrades very slowly.
Soil Absorption/Mobility: Absorbs strongly to soil, sediment, and particulates.

Section 13 - Disposal Considerations

Disposal: DDD is a potential candidate for rotary kiln incineration. Activated carbon can be used to remove most DDD from wastewater (to levels < 1 mg/L). Contact a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
Container Cleaning and Disposal: Triple rinse containers before disposal or shipment to scrap metal facility.

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): U060
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 Toxic Chemical (40 CFR 372.65): Not listed
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
OSHA Regulations:
Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A): Not listed

Section 16 - Other Information

References: 73, 103, 124, 184, 189, 197, 198
Prepared By..................................M Gannon, BA
Industrial Hygiene Review..........DJ Wilson, CIH
Medical Review ....T Thoburn, MD, MPH

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Material Safety Data Sheet Collection

Dieldrin **MSDS No. 940**

Date of Preparation: 12/94

Section 1 - Chemical Product and Company Identification

45

Product/Chemical Name: Dieldrin

Chemical Formula: $C_{12}H_8Cl_6O$

CAS No.: 60-57-1

Synonyms: Alvit; Dieldrite; HEOD; 1,2,3,4,10,10-hexachloro-6,7-epoxy,1,4,4a,5,6,7,8,8a, octahydro-endo-1,4-exo-5,8-dimethanonaphthalene; insecticide no. 497; Octalox; Quintox

Derivation: By oxidation of aldrin with peracids. Dieldrin also occurs in the environment as a *degradation* product of aldrin.

General Use: Used widely as an insecticide until 1974 when its use agriculturally was banned. Use as a moth-proofing agent for woolen goods and for termite control continued for several years, but as of 1992, it is no longer produced or used in the US. Still used in some countries for the control of malaria mosquitoes and other related vector-borne diseases.

Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Dieldrin, ca 85%wt + ca 15%wt other related active ingredients (technical grade).

OSHA PEL
8-hr TWA: 0.25 mg/m^3 (skin)

ACGIH TLVs
TWA: 0.25 mg/m^3 (skin)

NIOSH REL
10-hr TWA: 0.25 mg/m^3 (skin)
LOQ:* 0.15 mg/m^3

IDLH Level
450 mg/m^3

DFG (Germany) MAK
TWA: 0.25 mg/m^3 (skin)
Category III: Substances with systemic effects
Onset of Effect: > 2 hr
Half-life: > shift length (strongly cumulative)

Peak Exposure Limit: 2.5 mg/m^3, 30 min. average value, 1/shift.

* LOQ = Limit of Quantitation

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Dieldrin exists as an odorless, white, crystalline solid (pure) or a light tan to brown powder (technical grade). It is a central nervous system stimulant that can cause symptoms ranging from dizziness to convulsions. It is readily absorbed through the skin. Although no longer produced or used in the US, dieldrin has been very persistent in the environment and poses a health hazard through exposure to contaminated soil, water, and vegetation. Exposure to dieldrin can occur at hazardous waste disposal sites or contaminated manufacturing areas, where the exposure is from surface contamination or contaminated soils.

Wilson Risk Scale	
R	1
I	3
S	1*
K	0

*Skin absorption

HMIS	
H	3†
F	0
R	0

† Chronic effects

PPE‡

‡Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin contact/absorption.

Target Organs: Central nervous system and possibly, the liver and kidneys (by analogy to animals).

Acute Effects

Inhalation: Symptoms include hyperirritability, nausea and vomiting, headache, fatigue, dizziness, blurred vision, tremors, tonic/clonic convulsions, coma, and respiratory failure. It is possible that exposure may cause damage to the liver and kidneys, but thus far, this can only be confirmed in animal studies.

Eye: Dieldrin may be absorbed into the body by direct eye contact. Some local irritation may occur depending on what vehicle (solvent, oil) it is dissolved in.

Skin: Dieldrin is readily absorbed through the skin, producing greater toxicity than would occur from exposure via inhalation to the same concentration.

Ingestion: Effects similar to those caused via inhalation.

Carcinogenicity: NTP and OSHA do not list dieldrin as a carcinogen. IARC rates dieldrin as Group 3 (unclassifiable as to carcinogenicity in humans). Listed as a NIOSH Class X (carcinogen defined without further categorization) and EPA Class 2B (sufficient animal evidence; insufficient human evidence) carcinogen.

Medical Conditions Aggravated by Long-Term Exposure: Central nervous system disorders and possibly, liver and kidney disorders.

Chronic Effects: Repeated exposure may result in symptoms including fainting, muscle spasms, tremors, and weight loss.

Other: Dieldrin is stored unchanged primarily in the fatty tissue. It may cause teratogenic effects based on animal data.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air, monitor for respiratory distress, 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 min. Consult a physician or ophthalmologist if pain or irritation persist.

Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water. Wash thoroughly with soap, followed by a wash with alcohol and a second wash with soap. For reddened or blistered skin, consult a physician.

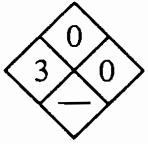
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, *do not* induce vomiting because of the potential for this material to cause seizures. Gastric lavage performed by a physician may be necessary.

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

Note to Physicians: Gastric lavage may be indicated in recent, substantial ingestions. Activated charcoal and sodium sulfate may also be beneficial. Urinalysis of halogenated compounds is a good indicator of exposure.

Section 5 - Fire-Fighting Measures

Genium



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: Dieldrin may become molten in heat of fire.

Hazardous Combustion Products: Hydrogen chloride and other chloride gases.

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 against dieldrin. Use protective clothing specifically recommended by the manufacturer.

Section 6 - Accidental Release Measures

Spill/Leak Procedures: Notify safety personnel. Cleanup personnel should protect against inhalation and skin/eye contact. Carefully scoop up or vacuum (with appropriate filter) and place in suitable containers. *Do not* sweep! If dieldrin is in solution, take up with earth, sand, vermiculite, or other absorbent, noncombustible material.

Containment: For large spills, flush with water to containment area for later disposal. Do not release into sewers or waterways.

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

Section 7 - Handling and Storage

Handling Precautions: Avoid dispersing dieldrin into the air. *Do not* wear leather clothing, gloves, or shoes.

Storage Requirements: Store in a cool, dry, well-ventilated area away from incompatibles.

Note: Because the manufacture and use of dieldrin is now banned in the US, storage should only be for the purpose of awaiting disposal.

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 concentrations below 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 workers exposed to dieldrin with emphasis on the 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 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. *Do not* wear *leather* clothing, gloves, or shoes! 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 dieldrin from your shoes and clean personal protective equipment. *Discard* any contaminated leather clothing, gloves, or shoes.

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

Section 9 - Physical and Chemical Properties

Physical State: Solid
Appearance and Odor: Odorless, white, crystals (pure); light tan to brown powder with a distinct chemical odor (technical grade).
Odor Threshold: (technical grade): 0.041 ppm
Vapor Pressure: 1.8 x 10^{-7} mm Hg at 77 °F (25 °C)
Formula Weight: 380.93
Density (H_2O=1, at 4 °C): 1.62 g/m^3 at 68 °F (20 °C)
Water Solubility: 0.186 mg/l
Other Solubilities: Slightly soluble in mineral oil and aliphatic hydrocarbons. Moderately soluble in aromatic hydrocarbons, halogenated solvents, esters, and ketones. Soluble in the following (grams of dieldrin/liter of solvent): acetone (220 g), ethanol (40 g), benzene (400 g), carbon tetrachloride (380 g), toluene (410 g), dichloromethane (480 g), methanol (10 g). 48g dieldrin/100 mL ethylene dichloride.
Boiling Point: Decomposes
Melting Point: 348.8 °F/176 °C (pure) ; ≥ 203 °F/95 °C (technical grade)

Section 10 - Stability and Reactivity

Stability: Dieldrin is stable at room temperature in closed containers under normal storage and handling conditions. Degrades in sunlight to form photodieldrin.
Polymerization: Hazardous polymerization does not occur.
Chemical Incompatibilities: Strong oxidizers, active metals such as sodium, mineral acids, acid catalysts, and phenols.
Conditions to Avoid: Exposure to excessive temperatures and incompatibles.
Hazardous Decomposition Products: Include hydrogen chloride and other chloride gases.

Section 11- Toxicological Information

Toxicity Data:*

Acute Inhalation Effects:
Rat, inhalation, LC_{50}: 13 mg/m^3/4 hr
Cat, inhalation, LC_{50}: 80 mg/m^3/4 hr caused excitement, somnolence, and convulsions or effect on seizure threshold.
Teratogenicity:
Mouse, oral, 15 mg/kg given on the 9th day of pregnancy caused specific developmental abnormalities (craniofacial, including nose and tongue).
Mouse, oral, 30.6 mg/kg given from 6 to 14 days of pregnancy caused specific developmental abnormalities of the central nervous system, ear, and eye.
Acute Dermal Effects:
Rat, skin, LD_{50}: 56 mg/kg

Acute Oral Effects:
Man, oral, LD_{Lo}: 65 mg/kg
Cat, oral, LD_{Lo}: 500 mg/kg caused pulmonary edema or fatty liver degeneration.
Rat, oral, LD_{50}: 38.3 mg/kg
Tumorigenicity:
Mouse, oral: 546 mg/kg administered continuously for 65 weeks produced liver tumors.
Mutagenicity:
Human, lymphocyte: 100 mg/L caused DNA inhibition.
Human, fibroblast: 1 µmol/L caused unscheduled DNA synthesis.

* See NIOSH, *RTECS* (IO1750000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Tadpoles, LC_{50} = 100 µg/l/96 hr; cutthroat trout, LC_{50} = 6 µg/l/96 hr.
Environmental Degradation: Dieldrin is very persistent in the environment. In soil, dieldrin will persist for > 7 yr. Its low water solubility and strong absorption to soil makes leaching unlikely. Some may volatilize from soil or be carried into the air via dust particles. In water, it will photorearrange to photodieldrin (half-life = 4 months). Biodegradation and hydrolysis do not occur. Bioconcentration will occur (BCF of 3 to 6000 in fish). In the air, dieldrin will photodegrade (rate not reported).

Section 13 - Disposal Considerations

Disposal: Dieldrin is a good candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C). See *Management of Hazardous Waste Leachate*, USEPA Contract N. 68-03-2766 (1982) for further discussion on disposal methods. 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: Dieldrin
Shipping Symbols: D
Hazard Class: 6.1
ID No.: NA2761
Packing Group: II
Label: Poison
Special Provisions (172.102): –

Packaging Authorizations
a) Exceptions: None
b) Non-bulk Packaging: 173.212
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 0.5 kg
b) Cargo Aircraft Only: 5 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): P037
CERCLA Hazardous Substance (40 CFR 302.4) listed per RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); and CWA, Sec. 307(a).
CERCLA Reportable Quantity (RQ), 1 lb (0.454 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)

Section 16 - Other Information

References: 73, 103, 124, 133, 136, 139, 176, 189, 192, 197, 201

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

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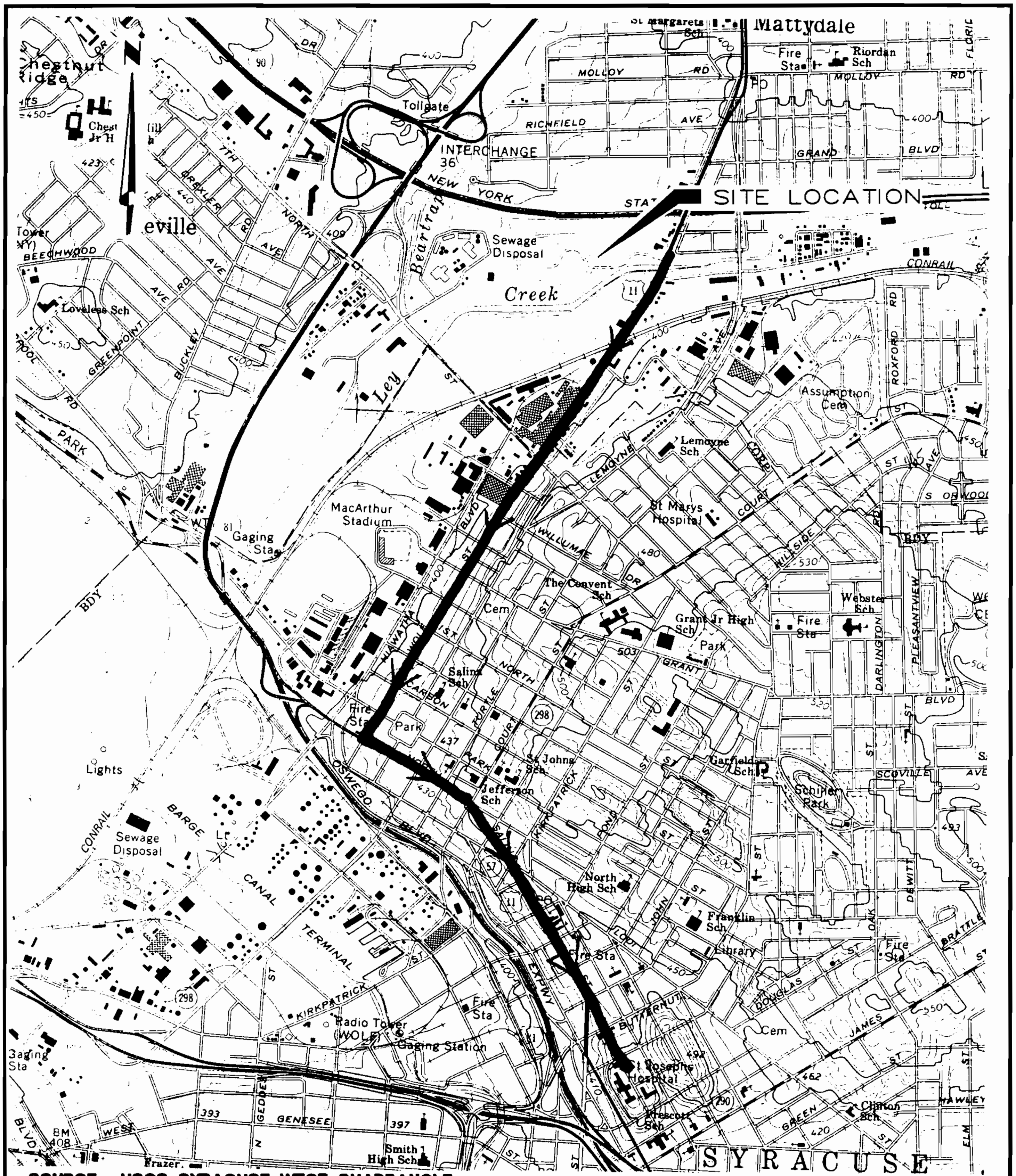
APPENDIX VII



SOURCE: USGS SYRACUSE WEST QUADRANGLE

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MAP TO HOSPITAL

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