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Southwest Division
Naval Facilities Engineering Command
Contracts Department
1220 Pacific Highway, Building 127, Room 112
San Diego, California 92132-5190

CONTRACT NO. N68711-98-D-5713
CTO NO. 0072

# FINAL

# BASE-WIDE HEALTH AND SAFETY PLAN

**Revision 0**
**April 23, 2004**

**HUNTERS POINT SHIPYARD**
**SAN FRANCISCO, CALIFORNIA**

**DCN: FWSD-RAC-04-1595**

TETRA TECH FW, INC.
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TETRA TECH FW, INC.

April 26, 2004
FWSD-RAC-04-1595
5.0

Naval Facilities Engineering Command
Southwest Division
Attn: Mr. Pat Brooks
1220 Pacific Highway
San Diego, CA 92132-5190

**SUBJECT: FINAL BASE-WIDE HEALTH AND SAFETY PLAN, REVISION 0, FOR HUNTERS POINT SHIPYARD, SAN FRANCISCO, CALIFORNIA.**

Reference: Contract N68711-98-D-5713, Environmental Remedial Action Contract For Sites Southern California, Arizona, New Mexico, and Southern Nevada

Dear Mr. Brooks

Enclosed is the Final Base-Wide Health and Safety Plan, Revision 0, for Hunters Point Shipyard, San Francisco, California. If you have any questions or require additional information, please contact me at (619) 471-3517.

Sincerely,

Glenn Starr
Project Manager

Enclosures: Final Base-Wide Health and Safety Plan

TETRA TECH FW, INC.

**TRANSMITTAL/DELIVERABLE RECEIPT**

**Contract No. N68711-98-D-5713 (RAC III)**

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Southwest Division
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Figure 12-1 Route to Clinic and Hospital

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| °F | degrees Fahrenheit |
| ABIH | American Board of Industrial Hygiene |
| ACGIH | American Conference of Governmental Industrial Hygienists |
| ACO | Administrative Contracting Officer |
| AHA | Activity Hazard Analysis |
| APR | air purifying respirator |
| Base-Wide Plan | Base-Wide Health and Safety Plan |
| BHASP | Building Health and Safety Plan |
| Cal-OSHA | California Occupational Health and Safety Administration |
| CCR | California Code of Regulations |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| CHEMTREC | Chemical Transportation Emergency Center |
| CIH | Certified Industrial Hygienist |
| CPR | cardiopulmonary resuscitation |
| CRC | Contamination Reduction Corridor |
| CSO | Caretaker Site Office |
| CSP | Certified Safety Professional |
| CTO | Contract Task Order |
| dBA | decibels, A-scale |
| Dig Alert | Underground Service Alert |
| DON | Department of the Navy |
| EHS | Environmental Health and Safety |
| EM | Engineer Manual |
| EMS | Emergency Medical Services |
| ESS | Environmental Safety Supervisor |
| FCR | Field Change Request |
| FEV10 | Forced Expiratory Volume, one second |
| FOPS | Falling Object Protective System |
| FVC | Forced Vital Capacity |

# ABBREVIATIONS AND ACRONYMS
(Continued)

| | |
|---|---|
| FWENC | Foster Wheeler Environmental Corporation |
| GFCI | Ground Fault Circuit Interrupters |
| HAZWOPER | Hazardous Waste Operations |
| HEPA | high-efficiency particulate air |
| HPS | Hunters Point Shipyard |
| kV | kilovolt |
| MSDS | Material Safety Data Sheet |
| MSHA | Mine Safety and Health Administration |
| NEC | National Electrical Code |
| NIOSH | National Institute for Occupational Safety and Health |
| OSHA | Occupational Safety and Health Administration |
| PCB | polychlorinated biphenyl |
| PESM | Project Environmental Safety Manager |
| PjM | Project Manager |
| PM | Program Manager |
| PPE | personal protective equipment |
| QC | Quality Control |
| RCRA | Resource Conservation and Recovery Act |
| ROICC | Resident Officer in Charge of Construction |
| RPM | Remedial Project Manager |
| RQ | reportable quantity |
| SCBA | self-contained breathing apparatus |
| SHSP | Site-Specific Health and Safety Plan |
| SHSS | Site Health and Safety Specialist |
| SWDIV | Southwest Division Naval Facilities Engineering Command |
| TLV | Threshold Limit Value |
| Triple A | Triple A Machine Shop, Inc. |
| TtFW | Tetra Tech FW, Inc. |
| TWA | time-weighted average |

# 1.0 INTRODUCTION

## 1.1 PURPOSE AND SCOPE

Tetra Tech FW, Inc. (TtFW), formerly Foster Wheeler Environmental Corporation (FWENC), has been contracted by the Department of the Navy (DON) to conduct remedial actions for the cleanup of hazardous waste sites under Southwest Division Naval Facilities Engineering Command (SWDIV) Remedial Action Contract N68711-98-D-5713. This Base-Wide Health and Safety Plan (Base-Wide Plan) applies to all work performed under these contracts at the Hunters Point Shipyard (HPS), San Francisco, California. The TtFW Health and Safety Program for HPS consists of this document, the TtFW Corporate Health and Safety Program Manual, and Site-Specific Health and Safety Plans (SHSPs) to be written for individual Contract Task Orders (CTOs) and modifications to these CTOs.

## 1.2 APPLICATION

The Contract Health and Safety Program is applicable to all work conducted by TtFW and TtFW subcontractors under the basic contracts and/or individual CTOs. Essentially equivalent or additional health and safety procedures and practices may be approved by TtFW and implemented by TtFW subcontractors where necessary. All subcontractors are required to follow the TtFW Health and Safety programs, and procedures, unless changes are approved by the TtFW Project Environmental Safety Manager (PESM), who is a Certified Industrial Hygienist (CIH), and the DON Contracting Officer. The TtFW PESM will review TtFW and subcontractor SHSPs prior to the initiation of fieldwork.

## 1.3 APPLICABLE STANDARDS, REGULATIONS, AND GUIDANCE DOCUMENTS

Adherence to applicable portions of federal, local, national consensus organization, and corporate health and safety standards, regulations, and guidance manuals is required during field activities. These include, but may not be limited to, the following:

- 29 Code of Federal Regulations (CFR), Part 1910, Occupational Safety and Health Standards, General Industry
- 29 CFR, Part 1926, Occupational Safety and Health Standards, Construction Industry 10 CFR, Part 20, Nuclear Regulatory Commission
- State Regulations including Title 8 California Code of Regulations (CCR) [California-Occupational Health and Safety Administration (Cal-OSHA)] and Title 24 CCR (Health and Safety Code)
- TtFW Corporate Health and Safety Program Manual

- TtFW Project Rules Handbook
- Navy/Marine Corps Installation Restoration Manual, August 2000
- U.S. Army Corps of Engineers Safety and Health Requirements Manual, Engineer Manual (EM) 385-1-1, 3 September 1996
- Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists (ACGIH), most current publication
- Occupational Safety and Health Guidance for Hazardous Waste Site Activities (U.S. Department of Health and Human Services, 1985)

## 1.4 PLAN ORGANIZATION

This Base-Wide Plan discusses many activities that may be performed under this CTO at Hunters Point. However, each specific task is specified or detailed as work is planned for a specific building or area of HPS. This plan describes anticipated work activities and the hazards and control of those hazards for each work activity. Once the nature of the work to be performed in a building is determined, the Site Health and Safety Specialist (SHSS) will prepare a Building Health and Safety Plan (BHASP). The BHASP will incorporate the elements of this plan either by direct reference to section numbers or by using pages directly from this plan. The BHASP will be supplemented with detailed building-specific information. Safety requirements for specific equipment or work procedures will be described. The BHASP must be reviewed and approved by the PESM prior to the commencement of work in each building. For work areas that are outdoors, specific addenda to this plan will be prepared as SHSP. SHSPs can also be prepared in lieu of BHASPs.

## 1.5 SUMMARY OF MAJOR RISKS

The facility had activities associated with shipbuilding and repair, maintenance, storage, and transportation. HPS has a large number of buildings. A number of these buildings have not been used for many years. These buildings have been vandalized and have not been maintained. Most of the buildings have no power. While working inside these buildings, lack of illumination is a major hazard. The buildings have stairs and flooring that present many trip hazards. There are sumps that are potential fall hazards. There is a potential for contact with insects, rodents, and snakes. There is potential contamination in various areas of the buildings. Contaminants may include fuels, solvents, metals, oils, polychlorinated biphenyls (PCBs), asbestos, lead-based paints, and low-level radioactivity. Some buildings are currently in use by tenants. These tenants include artists, equipment and machinery repair companies, and other industrial occupants. The San Francisco Police Department has facilities and training areas on HPS. Work required by this CTO may require work in the vicinity of these tenants. Although a security fence surrounds the entire facility, the facility has had trespassers, vagrants, and scavengers. There is a Defense Department Police Force on the facility.

# 2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

## 2.1 PROGRAM MANAGER

The Program Manager (PM) has the overall responsibility for the health and safety of site personnel at all projects under this contract. The PM will ensure that adequate resources are provided to the field health and safety staff to carry out their responsibilities as outlined below. The PM will also ensure that fieldwork is scheduled with adequate personnel and equipment resources to complete the job safely.

## 2.2 PROJECT MANAGER

The Project Manager (PjM) is responsible for managing all technical and business aspects of the project. This includes the development of the best technical approach and budget for the CTO scope, managing technical, cost, schedule, and project issues as work progresses, and subcontractor oversight. The PjM will also ensure that adequate personnel and resources are available to complete the project safely. TtFW Environmental Health and Safety (EHS) Procedure 1-2 specifies that line managers (PjMs, Site Superintendents, and Site Supervisors) have the responsibility to integrate loss control principles into all operations and to ensure that:

- All projects are implemented in compliance with all environmental, safety, and health laws and regulations, EHS program requirements, and Environmental Management System requirements.
- EHS plans are developed, approved, and implemented in accordance with TtFW requirements.
- Personnel understand the requirements of the project EHS plan(s) and each individual understands his/her responsibility for plan implementation.
- Personnel have all required training and are capable of performing all assigned tasks.
- Facilities and equipment meet TtFW and government regulations.
- Work rules are enforced.
- Inspections and incident investigations are conducted per program requirements. The PjM or designated manager will conduct monthly health and safety inspections of the jobsite.
- Effective corrective actions are implemented in a timely manner following inspections, audits, incident investigations, and so forth.
- Clients are notified of TtFW incident reporting procedures.
- Appropriate disciplinary action is implemented by line supervision when necessary.

## 2.3 SITE SUPERINTENDENT

The Site Superintendent is responsible for ensuring that all work is performed in accordance with the contract requirements in a safe and healthful manner. As a line manager, the Site Superintendent has the same responsibilities for health and safety program implementation as the PjM. The Site Superintendent will:

- Ensure that work crews have adequate resources to effectively conduct field activities.
- In conjunction with the SHSS, ensure that proper protective equipment is being used by all personnel.
- Ensure that appropriate disciplinary actions are taken when health and safety requirements are not being followed or when unsafe practices occur.
- Oversee work practices to verify that they are in accordance with the SHSP.
- Understand and be familiar with the SHSP.
- Participate in the daily tailgate safety meetings.
- Observe project personnel for signs of chemical or physical trauma.
- Immediately notify the SHSS and the PESM of any illness, accident, injury or near-miss incident.
- Correct any hazards disclosed by project workers or the SHSS.

The Site Superintendent has the authority to suspend field activities if the health and safety of personnel are in danger.

The Site Superintendent will submit to the DON Administrative Contracting Officer (ACO), upon request, copies of the certificates (or acceptable alternative documents) of most recent health and safety training required by 29 CFR, Part 1910.120 for all the personnel who will be working on site. Copies of the training certificates (or acceptable alternative documents) will also be kept at the work site.

## 2.4 PROJECT ENVIRONMENTAL SAFETY MANAGER

The PESM is responsible for implementing and overseeing the Contract Health and Safety Program and to develop, implement, and approve all SHSPs. Any changes to the established Contract Health and Safety Program or SHSP at the direction and approval of the PESM, with concurrence of the DON ACO. The PESM or designee will not necessarily be on site during all remedial activities, but will be readily available for consultation when required.

The PESM or designee is a CIH certified by the American Board of Industrial Hygiene (ABIH). The PESM supervises and directs the activities of the SHSS. The PESM has the authority to stop

unsafe operations, remove unqualified personnel from the work area, and approve changes to the SHSP. Duties of the PESM include:

- Overseeing all aspects of the SHSP from development to implementation.
- Advising the SHSS on all related health and safety aspects.
- Reviewing site-specific plans for completeness and compliance.
- Reviewing other site documents as they affect health and safety [Activity Hazard Analyses (AHAs), Sampling Plans].
- Reviewing and evaluating all monitoring results.
- Establishing and monitoring all related health and safety procedures through site safety inspections and audits.
- Ensuring that TtFW employees receive required EHS regulatory training.
- Fulfilling specific responsibilities for project EHS personnel that are identified within each EHS procedure.
- Functioning as a technical resource for all environmental compliance, safety, loss control, and industrial hygiene issues.

## 2.5 SITE HEALTH AND SAFETY SPECIALIST

The SHSS will be present on site, as required, during the conduct of field operations and is responsible for all health and safety activities and the delegation of duties to the health and safety staff in the field. The SHSS is responsible for implementation of the SHSP, seeing that appropriate personal protective equipment (PPE) is used relative to the hazard that may be encountered, verifying that communication systems are in place, monitoring conformance with safety and emergency response procedures, giving safety briefings, seeing that safety equipment is maintained, and conducting safety drills and exercises. The SHSS or designee is responsible for the setup and execution of decontamination procedures. The SHSS has stop work authorization, which will be executed upon determination of an imminent safety hazard or potentially dangerous situation. Work cannot restart until clearance has been authorized by the SHSS. The SHSS is responsible for maintaining the site health and safety logbooks.

The SHSS possesses the knowledge and experience necessary to ensure that all elements of the approved SHSP are implemented and enforced on site. TtFW employs full-time personnel as Environmental Safety Supervisors (ESSs) and personnel who have been cross-trained as ESSs. The ESS is the equivalent of the SHSS. Each TtFW SHSS has a minimum of 6 months work experience with hazardous materials and has completed a minimum of 40 hours additional specialized training in personal and respiratory protective equipment, program implementation, and in proper use of air monitoring instruments, air sampling methods, and interpretation of results. Every SHSS is certified as having completed training in first aid and cardiopulmonary

resuscitation (CPR) by a recognized organization such as the American Red Cross Association. TtFW EHS Procedure 1-2 states that the SHSS has the responsibility to:

- Ensure that TtFW employees understand the requirements of TtFW EHS programs and procedures through training and communication.
- Develop or assist with the development of EHS plans in conjunction with project personnel.
- Assist management with EHS plan implementation.
- Perform specific tasks in accordance with EHS plans.
- Fulfill the specific responsibilities for project EHS personnel that are identified within each EHS procedure.

Additional responsibilities, as described in the TtFW EHS program, include but are not limited to:

- Investigating of all accidents, injuries, illnesses, near-misses, and other incidents.
- Ensuring that employees are trained on the hazards of hazardous substances used on any project. Maintain Material Safety Data Sheet (MSDS) file to provide easy access to all employees; performing inspections to ensure that all containers are labeled.
- Ensuring that the SHSP is read, understood, and signed by all field personnel including subcontractors.
- Ensuring that tailgate safety meetings are conducted on days that work is performed; ensuring that documentation of all meetings and any other additional training is documented.
- Assessing employee exposure through specified monitoring protocols and ascertaining that protective measures are appropriate.
- Verifying that project safety equipment is inspected, as required by EHS program.
- Reporting to the Resident Officer in Charge of Construction (ROICC), within 24 hours, all incidents required to be reported by EM 385-1-1; immediately report to the ROICC any fatal injury, one or more persons admitted to a hospital, or property damage to government property.
- Verifiying that all personnel have the necessary training and medical clearance prior to entering the exclusion zone or contamination reduction zone of any site. The SHSS will inform the Site Superintendent of any site personnel with medical restrictions.
- Determining and posting routes to medical facilities and emergency phone numbers; arranging for emergency transportation to medical facilities.
- Maintaining training records and medical certifications for all on-site personnel including subcontractors.
- Serving as the Project Hazard Communication Coordinator.

On each project with an EHS plan, an ESS, is assigned to assist line management with EHS Program implementation. The ESS may have collateral duties.

## 2.6 SITE PERSONNEL

The PjM or Site Superintendent will select, as needed, personnel to function as supervisors. Supervisors will ensure that their subordinates comply with all requirements of this plan. A list of personnel authorized to have access to the remediation or worksite will be compiled and maintained on site by the SHSS. This list will include employees of TtFW, subcontractors, and representatives of governmental agencies that may require access, where possible. All authorized personnel shall meet the requirements of the CTO SHSP and be approved by the SHSS or Site Superintendent prior to entering any exclusion zone or controlled area when potentially hazardous activities are being conducted.

Although the employer is responsible for providing a safe and healthful workplace, each employee is responsible for their own safety as well as the safety of those around them. Employees will use all equipment provided in a safe and responsible manner as directed by the Site Superintendent. All TtFW personnel will follow the policies set forth in this SHSP and in the TtFW Environmental Health and Safety Program Manual. Each employee is responsible for immediately reporting any injuries, incidents, and safety infractions to a project supervisor or the SHSS so treatment can be obtained and/or corrective action taken. Equipment operators are responsible for the maintenance, inspection, and safe operation of their equipment. They will report any equipment malfunctions or necessary repairs to a project supervisor.

## 2.7 PROJECT CONSTRUCTION QUALITY CONTROL MANAGER

The project Construction Quality Control (QC) Manager inspects the preparatory and initial phases of projects for compliance with health and safety requirements.

## 2.8 SUBCONTRACTED PERSONNEL AND THIRD PARTIES

All subcontracted personnel are responsible for compliance with this SHSP and other applicable regulations. Subcontractor personnel must receive a briefing from the SHSS prior to unescorted access to the project site. They must fulfill the requirements established by this plan and the CTO site-specific plans. They must acknowledge receipt of the plan and the hazard communication briefing. On-site subcontractors are responsible for providing their personnel with appropriate PPE as specified by the plan. Subcontractor and third-party personnel have the authority to request a work area hazard assessment by the SHSS prior to the commencement or continuation of work.

Subcontractors will:

- Provide updated documentation of all training [Hazardous Waste Operations (HAZWOPER) refresher training, waste management training, and so forth] and medical certification for work in the exclusion zone and contamination reduction zone.
- Report all incidents and accidents immediately to the Site Superintendent or the SHSS.
- Have a Drug-free Workplace Program in compliance with the Federal Drug-free Workplace Act.

# 3.0 SITE HISTORY AND PROJECT DESCRIPTION

The following sections provide a description of HPS and its history.

## 3.1 SITE DESCRIPTION AND BACKGROUND

HPS was acquired by the DON in 1940. The main portion of HPS is situated on a long promontory located in the southeastern part of San Francisco, extending eastward into San Francisco Bay. The promontory is bounded on the north and east by San Francisco Bay and on the south and west by the Bayview/Hunters Point District of San Francisco. The on-base property at HPS consists of about 936 acres: 493, of which, are on land and 443, of which, are below bay waters. The area is divided into Parces A, B, C, D, E, and F (Figure 3-1). Parcel C is an approximate 79-acre tract of land located in the northeast portion of HPS. Parcel C has 37 buildings or other structures. Parcel D is an approximate 102-acre tract of land located in the southeast central portion of HPS. Parcel D has approximately 62 buildings. Parcel E is an approximate 135-acre tract of land located in the southern portion of HPS. Parcel E has 14 buildings or other structures.

## 3.2 HPS HISTORY

The promontory, on which HPS is located, has been recorded in maritime history since 1776, first as Spanish mission lands used for cattle grazing and later, in the 1860s, for its dry-dock facilities. In 1940, the U.S. government received title to the land at Hunters Point and began developing it as a shipyard. From 1945 to 1974, HPS was used predominantly as a repair facility by the DON. Additional acreage, mostly on the south side of the base, was acquired in 1957. The DON operated the shipyard as a ship repair facility through the late 1960s. HPS was deactivated in 1974 and remained relatively unused until 1976.

In 1976, the DON leased 98 percent of HPS to a private ship repair company, Triple A Machine Shop, Inc. (Triple A). Triple A leased the property from July 1, 1976, to June 30, 1986. Triple A did not vacate the property until March 1987. During the lease period, Triple A used dry-docks, berths, machine shops, power plants, various offices, and warehouses to repair commercial and DON vessels and also subleased portions of the property to various other businesses.

In 1986, the DON resumed occupancy of HPS. Many of the subtenants under Triple A's lease remained tenants under the DON's re-occupancy in 1986.

Because past shipyard operations left hazardous materials on site, HPS property was placed on the National Priorities List in 1989 as a Superfund site pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the

Superfund Amendments and Reauthorization Act of 1986. HPS then came under the administrative jurisdiction of the Treasure Island Naval Station in April 1990.

In 1991, HPS was slated for closure pursuant to the terms of the Defense Base Realignment and Closure Act of 1990. Closure activities at HPS involve environmental remediation activities and making the property available for non-defense use. On March 31, 1994, control of HPS was transferred from the Treasure Island Naval Station to the Naval Facilities Engineering Command, Western Division (now Engineering Field Activities, West) in San Bruno, California. In October 1999, SWDIV assumed management of HPS.

## 3.3 SURROUNDING LAND USE

The land at HPS can be divided into three functional areas: 1) the industrial production area, which consists of the waterfront and shop facilities for the structural machinery, electrical, and HPS service groups; 2) the industrial support area, which consists of supply and public works facilities; and 3) the non-industrial area, which consists of former DON personnel residential facilities, recreational areas, and a restaurant. The industrial production area occupies the north and east portions of HPS (Parcels B and C); the industrial support area occupies the south and southwest portions of HPS (Parcels D and E); and the non-industrial area occupies the northwest and central portions of HPS (Parcel A). Parcels B and E also contain non-industrial buildings. The land surface at Parcels B, C, and D is mostly covered by asphalt, buildings, or other structures. The majority of the land in Parcel E remains unpaved.

## 3.4 PROJECT DESCRIPTION

The projects that are anticipated under this CTO and other subsequent CTOs require radiation surveying and sampling in buildings, service areas, utilities and outdoor areas. Other remedial activities to be performed may include removal of contaminated debris, equipment, or materials such as soil. Other activities could include excavation, drilling, installation of monitoring wells, demolition of structures, and other similar activities that will prepare HPS for eventual transfer.

# 4.0 POTENTIAL HAZARDS

The SHSP for each task CTO or project will discuss the specific chemical, physical, and environmental hazards to workers on each specific site. The SHSP will discuss each contaminant and include information such as exposure limits and signs and symptoms of exposure. The SHSP will discuss site-specific physical hazards identified with the site, including those associated with construction, use of heavy equipment, fire hazards, and electrical hazards. This Base-Wide Plan discusses the general hazards associated with most projects. The SHSP will describe site-specific environmental hazards, although most environmental hazards are associated with the physical location of the base and weather conditions such as heat stress, noise, and flora and fauna contact, and are, therefore, described in this Base-Wide Plan.

## 4.1 CHEMICAL HAZARDS

The chemicals believed to be on a specific site, based on analytical data provided by previous investigations will be discussed in each SHSP. MSDSs for the contaminants and any additional chemicals found on a site or brought onto a site will be acquired and reviewed with all personnel during daily safety meetings. An attachment to the SHSP will contain the MSDSs. Attachment 1 of this Base-Wide Plan has the MSDS for some of the contaminants known to be at HPS. The PESM and the SHSS will specify the levels of protection and air monitoring requirements, based initially on the data provided or obtained prior to remediation work. These requirements may change as site conditions are more fully evaluated when work is underway.

TtFW's protective equipment requirements, combined with the requirement to wash arms, face, and hands before eating or smoking, should prevent exposure through these routes. In addition, the project SHSS and project supervisors observe and warn the crew members to be aware of the initial symptoms of chemical exposure. The amount of exposure depends primarily on the specific activities undertaken and the care with which the activities are performed. A supervisor will remove any crew member from the worksite and have the worker medically evaluated if the following initial symptoms persist and are unexplained by other causes (such as allergy, common cold, heat stress, and so forth):

- Dizziness or stupor
- Nausea, headaches, or cramps
- Irritation of the eyes, nose, or throat
- Euphoria
- Chest pains and coughing
- Rashes or burns

### 4.1.1 Hazard Communication Program

The purpose of a Hazard Communication or Employee Right-To-Know program is to ensure that the hazards of all chemicals located at this field project site are communicated according to 29 CFR, Part 1926.59 (8 CCR, Section 5194) regulations to all TtFW personnel and subcontractors. TtFW EHS Procedure 4-2 is the written hazard communication program. This program requires:

- ***Container Labeling***--Personnel will ensure that all drums and containers are labeled according to contents. These drums and containers will include those from manufacturers and those produced on site by operations. All incoming and outgoing labels will be checked for identity, hazard warning, and name and address of responsible party.
- ***MSDSs***--There will be an MSDS located on site for each hazardous chemical used or known to be on site.
- ***Employee Information and Training***--Training employees on chemical hazards is accomplished through formal safety training conducted annually and informal safety meetings. Project-specific chemical hazards are communicated to employees through an initial site orientation meeting and during daily safety meetings held at field projects.

## 4.2 ENVIRONMENTAL HAZARDS

The SHSS or a supervisor will discuss environmental hazards associated with each site at the orientation meeting prior to startup of remediation activities. As stated earlier, most environmental hazards are found base-wide and are a general concern to every project on the HPS.

### 4.2.1 Weather and Heat Stress

With the possible combination of ambient factors such as high air temperature, a few days with high relative humidity, low air movement, high radiant heat, and protective clothing, the potential for heat stress is a concern. The potential exists for:

- Heat rash
- Heat cramps
- Heat exhaustion
- Heat stroke

The TtFW EHS Procedure 4-6 describes the heat stress management and prevention program. At 75 degrees Fahrenheit (°F), ambient temperature, the supervisor on site initiates the procedures in the program.

Heat stroke, heat cramps, and heat exhaustion are covered in detail during the 40-Hour Occupational Safety and Health Administration (OSHA) 29 CFR, Part 1910.120 (8 CCR, Section 5192) pre-employment course. In addition, this information is discussed during a safety "tailgate" meeting before each workday where heat stress may be a factor. Workers are encouraged to increase consumption of water and electrolyte-containing beverages such as Gatorade during warm weather. Water and electrolyte-containing beverages will be provided on site and will be available for consumption during work breaks.

At a minimum, workers will break every 2 hours for 10 to 15 minute rest periods. In addition, workers are encouraged to take rests whenever they feel any adverse effects, especially those effects that may be heat-related. The frequency of breaks may need to be increased upon worker recommendation or decision of the SHSS and a supervisor.

The EHS procedure also describes a cold stress program; however, due to the location of the HPS, it is unlikely that there will be a need for this program.

Workers need to protect themselves from sunburn. Workers should wear clothing that protects them from the sun or otherwise wear a sunscreen lotion with a skin protection factor of 15 or greater. TtFW will provide sunscreen lotion to all workers. It is preferred to use a sunscreen lotion that is resistant to sweating.

### 4.2.2 Hearing Conservation Program

On projects where noise levels may exceed a time-weighted average (TWA) of 84 decibels, A-scale (dBA), hearing protection will be made available to all exposed employees. Additionally, sound level monitoring may be conducted on site. All TtFW personnel on project sites have annual audiograms. Personnel with a standard threshold shift will be restricted from high noise exposure or will be required to wear hearing protection at all times. TtFW EHS Procedure 4-4, is a hearing conservation program in compliance with OSHA regulations (29 CFR, Part 1910.95) (8 CCR, Sections 5095 through 5100).

### 4.2.3 Biological Hazards

Biological hazards may be encountered on site. Workers should anticipate the increased likelihood of encountering these hazards, especially in and around buildings and in undeveloped outdoor areas. Animal bites and insect stings can cause localized swelling, itching, and minor pain that can be handled by first aid treatment. In sensitized individuals, however, effects can be more serious such as anaphylactic shock, which can lead to severe reactions in the circulatory, respiratory, and central nervous system, and in some cases, even death. The SHSS will identify personnel with a known reaction to bites and stings at the pre-job safety orientation meeting. Personnel will not attempt to capture or feed any wild or semi-wild animals such as cats, rats or ground squirrels due to the possibility of a bite or parasitic infestation.

- Poison oak causes discomfort, irritation, and inflammation of the skin. Personnel will be warned to prevent contact with unknown plants. Protective clothing worn by site personnel should reduce the probability of such exposure. Cleaning the skin thoroughly with soap and water after contact will also reduce risk of severe symptoms.
- Animal and bird droppings often contain mold, fungus, or bacteria that represent a significant respiratory hazard including lung diseases and allergies. Personnel will not touch visual droppings and will wear gloves and Tyvek protective wear, at a minimum, when going into normally limited access areas such as crawl spaces and high ceilings that may have become refuges or nesting areas.
- The hantavirus is sometimes transmitted by rodents found in the Southwestern United States, and causes respiratory distress, sometimes with fatal consequences. Similarly rats transmit the arenavirus. Transmission of the hantavirus or arenavirus occurs with exposure to rodent droppings. Good hygiene practices such as washing hands and face prior to eating and drinking will help to minimize the potential for exposure to the hantavirus. While work is in progress, use of high-efficiency particulate air (HEPA) filter cartridges and work practices that minimize generation of dust and aerosols, will help protect employees. Avoiding areas where there are concentrations of mouse droppings (hantavirus) or rat droppings (arenavirus), for example, minimizes exposure to either virus. The virus can be inhaled in the dust from areas where mice or rats have nested or left their droppings. Minimizing dust inhalation or avoiding these areas will lessen the risks of exposure. Any work in such areas should be done only with full Level C protection including, at a minimum, a HEPA air-purifying respirator. Thorough washing of hands and face after removing the PPE will further minimize the potential for exposure.
- Personnel must use extreme caution when walking through an area, around buildings, and near objects such as drums and containers where a snake is likely to rest during the daytime. If a snake is encountered, slowly and quietly back away from the snake and inform all personnel of its location. Do not attempt to move or kill a snake as certain snakes are protected under state and federal laws. In the event of snakebite, do not try to move the affected individual. Wipe off the skin, as the venom will attack intact skin. Do not suck out the venom. Do not cut open the wound. Do not apply ice or ice packs. Do not use a tourniquet. Do not administer alcohol or medications. Call for medical assistance.

### 4.2.4 Storm Protection

If a warning of gale-force winds is issued, take precautions to minimize danger to persons, and protect the work and any nearby property. Precautions will include closing of all openings; removing loose materials, tools and equipment from exposed locations; and removing or securing scaffolding and other temporary work. Close all openings in the work site if storms of a lesser intensity pose a threat to property. The SHSS will ascertain predicted daily weather conditions by listening to daily weather forecasts on radio or television. If particularly ominous weather conditions are predicted, the SHSS will monitor radio broadcasts regularly or through

National Weather Service reports. Workers will not enter any excavations during a rainstorm. The supervisor or SHSS will stop all work when wind speeds are 25 miles per hour or higher. The supervisor and the SHSS will assess what work procedures can be safely performed when wind conditions exceed 25 miles per hour. They will give consideration to fugitive dust and odor emissions, the safety of equipment in high winds, and protection of workers from flying debris and dust in windy conditions. No crane or boom work is permitted in winds at 25 miles per hour or higher. (Certain crane manufacturers may specify lower wind speed limitations for safe operations. The SHSS must ensure that operational limitations of these cranes are not exceeded.) Projects near, in or on water will stop work and conditions will be evaluated before allowing work to continue. The bay can become dangerous when there are high winds or high tides. The project SHSS and superintendent will make a decision as to whether work can continue, continue work with modifications, or work is stopped.

## 4.3 PHYSICAL HAZARDS

There are numerous physical hazards associated with a project, which if not identified and addressed, could present accidents and personal injury to the workforce, as well as operational problems. In order to minimize physical hazards, TtFW has developed standard safety protocols, which will be followed at all times. Failure to follow safety protocols or continued negligence of these policies will result in discipline of the employee. The TtFW Project Rules Handbook states the health and safety project rules and guidelines. Some of these are described in this section and in Section 10.0 of this plan. Any site-specific rules are stated in the SHSP. All TtFW personnel will follow these requirements as specified here and in the Project Rules Handbook. Supervisors will observe the general work practices of each worker and enforce safe procedures to minimize physical hazards. Hard hats, safety glasses, and safety boots are required in all areas of the worksite, unless specifically exempted by the PESM, SHSS, or a supervisor.

### 4.3.1 Tripping, Slipping, and Falling Hazards

Supervisors will remind personnel and subcontractors daily to maintain sure footing on all surfaces. The supervisor and/or the SHSS will inspect all work areas prior to the start of work to look for hazards. Where engineering controls such as guardrails cannot be intalled or used, personnel working 6 feet above any surface, including man lifts, are required to wear safety harnesses and safety lanyards. The SHSS will inspect these before use. In order to minimize tripping hazards caused by debris, job supplies, and equipment, personnel will remove this material from the work areas daily and stockpile the materials and place equipment in storage areas. The SHSS will enforce this "housekeeping" effort throughout the day. Workers will not work near the edges of excavations without fall protection.

### 4.3.2 Head and Back Injuries

At a minimum, workers will don hard hats, safety boots, and safety glasses prior to performing any site activities. This will prevent minor injuries caused by bumping one's head while working around and under piping and other process-related structures or equipment. Personnel are instructed in proper lifting techniques and will not lift heavy items without assistance per TtFW EHS Procedure 3-1. Each worker will not lift more than 50 pounds. Objects heavier than 50 pounds require assistance from another person. Supervisors will use mechanical lifting equipment whenever possible to minimize worker exposure to lifting hazards.

### 4.3.3 Falling Objects

All items raised will be slowly lowered to the ground using a grapple and/or skip bucket. No personnel will work under equipment at any time. Also, the SHSS will ensure that an adequate area is clear of personnel while the equipment is in operation. Dump truck drivers will remain in their trucks while soil and debris is placed in their trucks, if their trucks are equipped with a Falling Object Protective System (FOPS). If their trucks are not equipped with a FOPS, the drivers will get out of their trucks and stand clear of the loading operation. Workers will not work under other workers, who are on scaffolds or levels higher than them, unless those levels have protection to prevent objects from falling on workers below.

### 4.3.4 Heavy Equipment and Traffic

The use of heavy equipment for debris removal, excavation, and lifting presents the greatest potential for injury to personnel. In order to minimize these hazards, the PM and supervisor will designate routes for mobilization through the HPS and establish specific traffic patterns. All trucks and heavy equipment will have spotters for backing maneuvers. Only qualified personnel will operate heavy equipment. Those crewmembers directly involved with spotting for the operator are the only personnel allowed in the vicinity of the heavy equipment. All others will remain a safe distance away from these operations. Personnel needing to approach heavy equipment while operating will observe the following protocols:

- Make eye contact with the operator (and spotter)
- Signal the operator to cease heavy equipment activity
- Approach the equipment and inform the operator of intentions

All TtFW personnel will follow all local traffic rules. Company vehicles will yield to all bikes and pedestrians. Personnel working in areas subject to vehicular traffic (streets, parking lots, and so forth) will wear orange safety vests. Flashing light or reflectorized barricades will be used for all roads that are blocked due to equipment or excavation. Coordinate all traffic management issues with the Remedial Project Manager (RPM) and HPS security.

#### 4.3.4.1 Site Pre-Inspection of Equipment

The projects will only use heavy equipment that is in safe working order. To maintain this policy, the project supervisor(s), the SHSS, and the equipment operator will inspect all equipment brought onto the project site for structural integrity, smooth operational performance, and proper functioning of all critical safety devices in accordance with the manufacturer's specifications and safety regulations. A competent person will inspect all equipment brought on to the site and certify that equipment has been inspected and is safe to operate. There will be an operator's manual for each heavy equipment and vehicle. All equipment not conforming to the operational and safety requirements set forth during this inspection will not be put into service until all necessary repairs are made to the satisfaction of the inspection group. A form for documenting these inspections is included in Attachment 2.

#### 4.3.4.2 Operator Qualifications

Only qualified operators familiar with the equipment to be used will be permitted to operate. Subcontractors will supply proof of their operator's capability and experience to operate the equipment in a safe manner. TtFW reserves the right to remove any operator from the project site if there is a question or doubt concerning the operator's capabilities. There are specific training requirements for industrial truck (forklift) operators and for crane operators. These requirements are specified in the TtFW EHS procedures and the U.S. Army Corps of Engineers EM 385-1-1 Safety and Health Requirements Manual.

### 4.3.5 Electrical Hazards

In order to prevent accidents caused by electric shock, the project SHSS will inspect all electrical connections on a daily basis. The SHSS will shut down and lock out any equipment that is found to have frayed or loose connections until a qualified electrician is contacted and repairs are made. The equipment will be de-energized and tested before any electrical work is done. All equipment will be properly grounded prior to and during all work. In addition, ground fault circuit interrupters (GFCIs) will be installed for each circuit between the power source and tool for all outdoor use. In the event that generators are used to supply power, these generators will contain GFCIs.

Requirements for electrical safety include:

- All electrical wiring and equipment will be listed by a recognized testing laboratory. In California, the usual recognized testing laboratories are Underwriters Laboratory, Canadian Standards Association and Factory Mutual. There are six other recognized laboratories that are rarely ever seen in the certification of electrical equipment. Some equipment manufactured in foreign countries have other listing certifications. Most foreign certifications are not recognized as meeting the standards in California.

- Live parts of wiring and equipment will be guarded to protect all persons or objects from harm. Uninsulated live wires must be placed at various heights and distances from the ground and from buildings depending on the voltage carried by those lines.
- Transformer banks and high-voltage equipment will be protected from unauthorized access.
- A qualified electrician will perform all work on electrical power supplies and lines.
- Flexible cords (extension cords) will contain the number of conductors required for service plus a ground wire. Cords will be rated for hard usage (S, SE, SEO, SO, SOO, ST, STO, STOO). (Note, this rating is not required to be listed on the cord itself, so check the wrapping or label that comes with the cord to assure that the cord meets this requirement.) Flexible cords are not allowed to pass through doors, windows, or be placed on the ground where they are subject to being run over by vehicles. If flexible cords must pass through walls, the cords will be protected by bushings or fittings.
- Flexible cords must be inspected on each day of use. No splices or fraying is allowed.
- Flexible cords will not be secured with staples, hung from nails or suspended by pare wire. (Plastic tie straps, commonly used today, are acceptable.)
- All portable lamps must have bulbs protected by a substantial guard and attached to the lamp holder handle.
- All circuit breaker panels and electrical transformers and supply equipment must be labeled as to the voltage contained therein.
- All circuit breaker panels must be labeled as to what each breaker controls.
- All breaker panels and electrical panels must have a cover protecting any live exposed wires.
- At least a 30-inch clearance must be maintained on three sides of all circuit breaker boxes, transformers, and electrical supply equipment so as to provide ready access to the equipment in the event of an emergency. A 36-inch clearance is required for higher voltages, so to assure that adequate clearance is provided, TtFW requires a 36-inch clearance of all breaker boxes, and so forth.
- Circuit breaker boxes that are locked or kept in locked rooms must have a key readily available in the event of an emergency.

#### 4.3.5.1 Portable Generators

Portable generators are used on many construction sites. Portable generators must meet the requirements for grounding as specified in the National Electrical Code (NEC) National Fire Protection Association 70. NEC 250-6 has certain exemptions for the grounding of portable and vehicle-mounted generators. Refer to the code to EM 385-1-1, Section 11 for additional details. Portable generators will be operated in open air only where there is sufficient ventilation as to prevent accumulation of exhaust gases including carbon monoxide.

#### 4.3.5.2 Temporary Wiring

A qualified electrician will design temporary wiring. A qualified engineer will approve the design. The system will be tested as required by EM 385-1-1, Section 11. Temporary lighting will be protected by guards and will not be suspended by the wire. Exposed empty light sockets and broken bulbs are not permitted. Temporary lighting circuits will be separate from electrical tool circuits. Circuits will be labeled as "LIGHTS ONLY" or "TOOLS ONLY."

### 4.3.6 Control of Hazardous Energy (Lock-Out/Tag-Out)

TtFW EHS Procedure 6-4, Lock-Out/Tag-Out, establishes the TtFW Control of Hazardous Energy Program. This program applies to all TtFW operations, except as follows:

- Work on cord and plug connected electrical equipment where the plug is under the control of the employee performing the work
- Hot tap operations
- Work involving minor changes and adjustments to equipment during routine operations (such as small tooling adjustments)

Following are the steps to be followed in preparing for, applying, and releasing a machine or piece of equipment from lock-out. These steps shall be completed, in order, using the corresponding permit. While work is being performed under the lock-out, a copy of the completed permit shall be posted at the equipment controls or work area as appropriate. (The steps below and this section of this plan refer to sections of the permit form.)

1. Complete the general information in Section A of the permit

2. Identify isolation points:

   The first step required to isolate a piece of equipment is to identify the sources of hazardous energy present. To identify the sources, the authorized employee shall complete the following steps:

   - Survey the equipment and related schematics, blueprints, or as-builts, if available, for hazardous energy sources
   - Identify the isolation points and device positions for controlling each source of hazardous energy
   - Identify the isolation method to be used on each source

   The above information shall be documented in Section B of the Lock-out/Tag-out Permit as each point is identified.

3. Notifications

Prior to applying a lock-out, the authorized employee shall notify affected employees of the equipment to be locked out and sign Section C of the Lock-out/Tag-out Permit on the "Notifier" line.

4. Equipment shutdown

Shut down the equipment or place into the desired configuration using normal operating procedures. The authorized employee shall sign Section C of the Lock-out/Tag-out Permit on the "Shutdown by" line.

5. Equipment isolation

To apply a lock out to a piece of equipment, complete the following steps:

- Place each energy isolation device into a position that will prevent the transmission of hazardous energy.
- The authorized employee shall lock out devices to each isolation point and control the key for each lock at all times. Only one key is permitted per lock.

Complete Section D of the permit as each device is placed and sign the "Isolator" line in Section C.

Notes:

- Any lock-out device not containing an integral locking mechanism must be used in conjunction with a keyed lock.
- Any energy isolation point not capable of being locked out must be controlled physically through such means as removal of handles and disconnecting.

6. Release of stored energy

After the equipment has been locked and tagged as required in Section D, all remaining stored energy must be released. Methods for the release of stored energy include, but are not limited to the following:

- Discharge and grounding of capacitors
- Bleeding pressure from vessels and lines
- Releasing mechanical sources of energy to engage blocks

Stored energy has the potential to reaccumulate; therefore, verification of isolation shall continue until work is complete. After releasing stored energy, complete Section E of the permit.

7. Lock-out/Tag-out verification

After completing the lock-out of the desired piece of equipment, the effectiveness of the lock-out must be verified by the authorized employee by attempting to operate the machine. After attempting to operate the machine, sign Section C of the permit on the "Verifier" line.

8. Performance of work

After verifying and receiving the supervisor's approval signature, work may be performed on the equipment, which was locked/tagged.

9. Lock-out/Tag-out removal

After work has been completed, the following steps shall be followed to release equipment from lock-out/tag-out:

- The area affected by the lock-out shall be inspected to ensure that releasing the machine does not present a hazard to people and property.
- Lock-out devices and tags shall be removed.
- Isolation devices shall be returned to their operating positions.
- The equipment will be started.
- Affected employees shall be notified of the release.
- Section F of the permit shall be completed as the equipment is returned to service.

#### 4.3.6.1 Tag-Out

The use of tags without locks are prohibited, except in those cases where it is physically impossible to attach a locking device to an isolation point. When it is necessary to use tags without locks, the following shall be completed:

- The isolation point shall be placed in the correct position to prevent the flow of energy.
- The device shall be physically disconnected.
- A tag shall be placed on the disconnected device.
- Employees shall be warned not to tamper with the tag or isolation point.

#### 4.3.6.2 Equipment-Specific Lock-out/Tag-out Procedures

As TtFW does not normally perform lock-outs of machinery on a repetitive basis the lock-out/tag-out permit contained in Attachment A is designed for initial and one-of-a-kind lock-outs. Should it become necessary to repetitively lock out the same piece of equipment, specific

procedures and permits for the equipment shall be developed. Information contained in the equipment-specific procedure and permit should be the same as the information in the Attachment A permit. The procedures shall be generated by trained and knowledgeable project personnel and be reviewed and approved by the PESM. Equipment-specific procedures are not required when all of the following conditions are present:

- The machine has no potential for stored energy or the reaccumulation of energy after shutdown.
- The equipment has a single, readily identifiable, and isolated source of energy.
- Isolation and lock out of the source will completely de-energize and deactivate the equipment.
- The machine is locked out and isolated from that energy source during servicing and maintenance.
- A single lock-out device will achieve a locked-out condition.
- The servicing or maintenance does not create a hazard to other employees.

#### 4.3.6.3 Shift Changes

If it is necessary to maintain the status of a locked out machine or device past the end of the shift when the lock-out was initially installed, the following procedures shall be adhered to:

- The incoming authorized employee shall place their lock on the lock-out point and complete a new permit.
- The outgoing employees shall remove their lock(s) after the new lock(s) are applied.
- If multiple shifts are not used, the initial locks may be left in place until the following day or until the equipment is released from lock-out/tag-out.
- The new shift supervisor shall sign the permit before work is begun on the new shift. The last supervisor whose name is on the lock-out/tag-out permit is responsible for all activities related to the work activity.

#### 4.3.6.4 Failure to Clear Locks

If a person should fail to clear a lock-out and their lock remains in place, the supervisor will attempt to contact the person who applied the lock and resolve the issue.

If the person cannot be contacted, the supervisor will investigate the situation and determine if removal of the lock will create a hazard in the work zone. If there is no hazard present, the supervisor will then verify that the work zone is clear, and blocking devices have been removed, and the system has been restored to the normal configuration. The supervisor will then cut the lock off and restore energy to the system.

A written incident and investigation report per TtFW EHS Procedure 1-7, Incident Reporting and Investigating, shall be prepared by the supervisor stating the reason for cutting the lock, why the lock was not removed, and the procedure used to ensure the safety of personnel in the area. The individual whose lock was cut off must be notified immediately.

#### 4.3.6.5 Subcontractors

The supervisor shall be familiar with the nature of any subcontractor work on site that may involve hazardous energy and assure that they follow work practices that are at least as strict as this procedure. For any lock-out/tag-out requirements, the supervisor shall review and approve all subcontractor work set up, apply his locks to the scheme, and sign the appropriate lock-out/tag-out procedure checklist.

#### 4.3.6.6 Periodic Inspections

Periodic inspections pursuant to EHS 3-3, Inspections, shall be completed during the monthly inspections by the SHSS, PESM or other qualified personnel to ensure that the lock-out/tag-out program is being effectively implemented. At a minimum, the following shall be done:

- Existing lock-outs will be reviewed for effectiveness.
- Permits for each existing lock-out shall be reviewed for adequacy.
- Incident reports and past permits shall be reviewed to determine if deficiencies in the program exist.
- Corrections to the system will be made as warranted.
- Results will be logged in the health and safety logbook.

#### 4.3.6.7 Training

Following are the training requirements for various personnel involved with or affected by lock-out/tag-out.

- Authorized employees shall receive training in the following prior to being allowed to use lock-out/tag-out procedures:
  - Recognition of hazardous energy sources
  - Types and magnitudes of energies available at the site
  - Methods and means needed for energy isolation and control
  - The requirements of this procedure and 29 CFR 1910.147

- Affected employees shall be instructed in the following:
  - Purpose of the lock-out/tag-out program
  - Use and requirements of this procedure and 29 CFR 1910.147
  - Prohibitions of restarting or tampering with equipment that has been locked out
  - Prohibitions of tampering with locks and tags installed on equipment

Personnel not employed by TtFW shall be briefed in the requirements of this program during site-specific orientations, when applicable. Training records shall be maintained in accordance with TtFW EHS Procedure 1-9, Recordkeeping.

### 4.3.7 Confined Space Entry

A confined space is any enclosed area having a limited means of egress where ventilation is not adequate to remove a toxic or flammable atmosphere or oxygen deficiency, which may exist. Examples of confined spaces include, but are not limited to, the following: tanks; boilers; vessels; bins; manholes; tunnels; pipelines; underground utility vaults; or any open top space more than 4 feet in depth such as pits, tubes, trenches, or vessels.

TtFW EHS Procedure 6-1 outlines procedures in detail. No confined space entry is allowed per this plan. Prior to the start and during the conduct of each CTO, the PESM, the SHSS and the project supervisor(s) will identify confined spaces or confined spaces created by the nature of the work. The SHSS will identify these confined spaces and will not allow entry into these spaces. If a confined space entry is part of the planned activities for a task within a SHSP, the SHSP will detail the confined space entry procedure and requirements. If a confined space requires entry, after an SHSP has been approved but was not part of the original SHSP, the SHSP will be modified and approved per the amendment procedure described in this Base-Wide Plan.

### 4.3.8 Fire and Explosion Hazards

Atmospheric testing with a combustible gas indicator must be performed to determine the potential for a flammable atmosphere. A hot work permit must be issued to control the presence of equipment or operations producing open flames or sparks. Hot work permits and procedures are found in TtFW EHS Procedure 6-5. Permits are issued by the SHSS. The SHSS must also obtain a hot work permit from the HPS Federal Fire Department. The SHSS must establish a fire prevention and protection program by ensuring that flammable materials are properly stored and that safe work procedures and rules are followed. Smoking is not permitted anywhere on a project site, except in designated areas.

### 4.3.9 Drilling

Any drilling will be performed in accordance with EM 385-1-1, 16.M. A survey of the job site to identify overhead electrical hazards, potential ground hazards, and underground utilities must be performed before placement of the drilling equipment. MSDSs for drilling fluids must be provided to the SHSS before the start of work. Supervisors will ensure that a call has been made to Underground Service Alert (Dig Alert) and that drawings and maps from public works are reviewed to verify that there are no underground utilities that will be disturbed by the drilling operation.

#### 4.3.9.1 Housekeeping

The drilling safety supervisor shall understand and fulfill the responsibility for proper maintenance and good "housekeeping" on and around the drill rig. These requirements include, but are not limited to:

- Provide suitable storage locations for all tools, materials, and supplies so that tools, materials, and supplies can be conveniently and safely handled without hitting or falling on a member of the drill crew or a visitor.
- Avoid storing or transporting tools, materials or supplies within or on the mast (derrick) of the drill rig.
- Neatly stack pipe, drill rods, casing augers, and similar drilling tools on racks or sills to prevent spreading, rolling or sliding.
- Place penetration or other driving hammers at a safe location on the ground or secure them to prevent movement when not in use.
- Keep work areas, platforms, walkways, scaffolding, and other access ways free of materials, debris, and obstructions and substances such as ice, grease or oil that could cause a surface to become slick or otherwise hazardous.
- Keep all controls, control linkages, warning and operation lights, and lenses free of oil, grease and/or ice.
- Do not store gasoline in any portable container other than a non-sparking, approved container with a flame arrestor in the fill spout and having the word "gasoline" easily visible. A hazard communication label shall also be placed on all gasoline cans. (See TtFW EHS 4-2, Hazard Communications, and TtFW EHS 3-7, Hazardous Material Storage and Transportation.)

#### 4.3.9.2 Maintenance

Proper maintenance will make drilling operations safer. Maintenance should be performed safely. These requirements include, but are not limited to:

- Keep drill rigs and associated equipment in good condition.
- Wear safety glasses when performing maintenance on a drill rig or on drilling tools.
- Shut down the drill rig engine to make repairs or adjustments to a drill rig or to lubricate fittings (except repairs or adjustments that can only be made with the engine running). Take precautions to prevent accidental starting of an engine during maintenance by locking, removing or tagging the ignition key (see TtFW EHS 6-4 Lock-out/Tag-out Procedure).
- Always block the wheels or lower the leveling jacks or both and set handbrakes before working under a drill rig.
- When possible and appropriate, release all pressure on the hydraulic systems, the drilling fluid system and the air pressure systems of the drill rig prior to performing maintenance. In other words, reduce the drill rig and operating systems to a "zero energy state" before performing maintenance. Use extreme caution when opening drain plugs and radiator caps and other pressurized plugs and caps.
- Do not touch an engine or the exhaust system of an engine following its operation until the engine and exhaust system have had adequate time to cool.
- Never weld or cut on or near a fuel tank.
- Do not use gasoline or other volatile or flammable liquids as a cleaning agent on or around a drill rig.
- Follow the manufacturer's recommendations for applying the proper quantity and quality of lubricants, hydraulic oils and/or coolants.
- Replace all caps, filler plugs, protective guards or panels and high pressure hose clamps and chains or cables that have been removed for maintenance before returning the drill rig to service.
- Check each deadman (emergency shut-off) switch daily. (Every drill rig must be equipped with two kill switches- one for the operator and one for the helper) Ensure that its location is known to all drill rig crew personnel.
- The client recommends the use of a cage around all rotating augers.

#### 4.3.9.3 Hand Tools

There are almost an infinite number of hand tools that can be used on or around a drill rig and in repair shops and more than an equal number of instructions for proper use. "Use the tool for its intended purpose" is the most important rule. The following are a few specific and some general suggestions, which apply to safe use of hand tools that are often used on and around drill rigs.

- When a tool becomes damaged, either repair it before using it again or discard it.
- When using a hammer, wear safety glasses and require all others around you to wear safety glasses.

- When using a chisel, wear safety glasses and require all others around you to wear safety glasses.
- Keep all tools cleaned and neatly stored when not in use.
- Use wrenches on nuts - do not use pliers on nuts.
- Use screwdrivers with blades that fit the screw slot.
- When using a wrench on a tight nut - first use some penetrating oil, use the largest wrench available that fits the nut, when possible pull on the wrench handle rather than pushing, and apply force to the wrench with both hands when possible and with both feet firmly placed. Don't push or pull with one or both feet on the drill rig or the side of a mud pit or some other blocking-off device. Always assume that you may lose your footing - check the place where you may fall for sharp objects.
- Keep all pipe wrenches clean and in good repair. The jaws of pipe wrenches should be wire brushed frequently to prevent an accumulation of dirt and grease, which would otherwise build up and cause wrenches to slip.
- Never use pipe wrenches in place of a rod-holding device.
- Replace hook and heel jaws when they become visibly worn.
- When breaking tool joints on the ground or on a drilling platform, position your hands so that your fingers will not be smashed between the wrench handle and the ground or the platform, should the wrench slip or the joint suddenly let go.

#### 4.3.9.4 Clearing the Work Area

Prior to drilling, perform adequate site clearing and leveling to accommodate the drill rig and supplies and provide a safe working area. Drilling shall not be commenced when tree limbs, unstable ground or site obstructions cause unsafe tool handling conditions.

#### 4.3.9.5 Startup

- Instruct all visitors to "stand clear" of the drill rig immediately prior to and during starting of any engine.
- Make sure all gear boxes are in neutral, all hoist levers are disengaged, all hydraulic levers are in the correct non-actuating positions, and the cathead rope is not on the cathead before starting a drill rig engine.
- Start all engines according to the manufacturer's manual.

#### 4.3.9.6 Safety During Drilling Operations

- Safety requires the attention and cooperation of every worker and site visitor.
- Do not drive the drill rig from hole to hole with the mast (derrick) in the raised position.

- Before raising the mast (derrick), look up to check for overhead obstructions. Ensure that slide hammer is secured and that no person places their hands or any part of their body on, in or near any moving parts.
- Maintain a minimum 15-foot clearance from all overhead electric lines. See U.S. Army Corps of Engineers, EM 385-1-1, Section 11.E for additional guidance on operations adjacent to overhead lines.
- Before raising the mast (derrick), all drill rig personnel (with the exception of the operator) and visitors shall be cleared from the areas immediately to the rear and the sides of the mast. All drill rig personnel and visitors shall be informed that the mast is being raised prior to raising it.
- Before the mast (derrick) of a drill rig is raised and drilling is commenced, the drill rig must first be leveled and stabilized with leveling jacks and/or solid cribbing. The drill rig shall be re-leveled if it settles after initial setup. Lower the mast (derrick) only when the leveling jacks are down, and do not raise the leveling jack pads until the mast (derrick) is lowered completely.
- Before starting drilling operations, secure and/or lock the mast (derrick) if required according to the drill manufacturer's recommendations.
- The operator of a drill rig shall only operate a drill rig from the position of the controls. If the operator of the drill rig must leave the area of the controls, the operator shall shift the transmission controlling the rotary drive into neutral and place the feed control lever in neutral. The operator shall shut down the drill engine before leaving the vicinity of the drill rig.
- Throwing or dropping tools shall not be permitted. All tools shall be carefully passed by hand between personnel or a hoist line shall be used.
- Do not consume alcoholic beverages or other depressants or chemical stimulants prior to starting work on a drill rig or while on the job.
- When encountering a "hot spot" during drilling operations involving volatiles, vacate the immediate area and allow the borehole to vent. Resume work after monitoring instruments indicate an atmosphere in compliance with the site-specific EHS Plan.
- If it is necessary to drill within an enclosed area, make certain that exhaust gases are vented out of the area. Exhaust gases can be toxic and some cannot be detected by smell.
- Clean mud and grease from your boots before mounting a drill platform and use hand holds and railings. Watch for slippery ground when dismounting from the platform.
- During freezing weather, do not touch any metal parts of the drill rig with exposed flesh. Freezing of moist skin to metal can occur almost instantaneously.
- All air and water lines and pumps should be drained when not in use if freezing weather is expected.
- All unattended boreholes must be adequately covered or otherwise protected to prevent drill rig personnel, site visitors or animals from stepping or falling into the

hole. All open boreholes shall be covered, protected or backfilled adequately and according to local or state regulations upon completion of the drilling project.

- "Horsing around" within the vicinity of the drill rig and tool and supply storage areas is not allowed, even when the drill rig is shut down.
- When using a ladder on a drill rig, face the ladder and grasp either the side rails or the rungs with both hands while ascending or descending. Do not attempt to use one or both hands to carry a tool while on a ladder. Use a hoist line and a tool "bucket" or a safety hook to raise or lower hand tools.
- Use elevated derrick platforms with the following precautions:
  - When working on a derrick platform, use a safety harness and a lifeline. The safety harness shall be at least 4 inches (100 millimeters) wide and shall fit snugly but comfortably. The lifeline, when attached to the derrick, shall be less than 6 feet (2 meters) long. The safety harness and lifeline shall be strong enough to withstand the dynamic force of a 250-pound (115 kilograms) weight (contained within the belt) falling 6 feet (2 meters).
  - When climbing to a derrick platform that is higher than 20 feet (6 meters), use a safety-climbing device.
  - When a rig worker is on a derrick platform, fasten the lifeline to the derrick just above the derrick platform and to a structural member that is not attached to the platform or to other lines or cables supporting the platform.
  - When a rig worker first arrives at a derrick platform, inspect the platform for broken members, loose connections, and loose tools or other loose materials.
  - Attach tools securely to the platform with safety lines. Do not attach a tool to a line attached to your waist or any other part of your body.
  - When you are working on a derrick platform, do not guide drill rods or pipe into racks or other supports by taking hold of a moving hoist line or a traveling block.
  - Do not leave loose tools and similar items on the derrick platform or on structural members of the derrick.
  - A derrick platform over 4 feet (1.2 meters) above ground surface shall be equipped with toe boards and safety railings that are in good condition.
  - Workers on the ground or the drilling floor shall avoid working under rig workers on elevated platforms, whenever possible.
- Terminate drilling operations during an electrical storm and move the entire crew away from the drill rig
- Do not wear loose clothing, jewelry, watches, or rings around operating drill rigs.

#### 4.3.9.7 Safe Use of Wire Line Hoists, Wire Rope and Hoisting Hardware

- The use of wire line hoists, wire rope and hoisting hardware shall be as stipulated by 29 CFR 1910, 29 CFR 1926, and the American Iron Steel Institute *Wire Rope Users Manual* (American Iron and Steel Institute, 1993).
- Visually inspect all wire ropes and fittings during use and thoroughly inspect them at least once a week for: abrasion, broken wires, wear, reduction in rope diameter, reduction in wire diameter, fatigue, corrosion, damage from heat, improper reeving, jamming, crushing, bird caging, kinking, core protrusion and damage to lifting hardware. Replace wire ropes when inspection indicates excessive damage according to the *Wire Rope Users Manual* (American Iron and Steel Institute, 1993). Thoroughly inspect all wire ropes that have not been used for a period of a month or more before returning them to service.
- End fittings and connections consist of spliced eyes and various manufactured devices. Install all manufactured end fittings and connections according to the manufacturer's instructions and follow the manufacturer's load specifications.
- If a ball-bearing-type hoisting swivel is used to hoist drill rods, inspect and lubricate the swivel daily to assure that the swivel freely rotates under load.
- If a rod slipping device is used to hoist drill rods, do not drill through or rotate drill rods through the slipping device, do not hoist more than 1 foot (0.3 meters) of the drill rod column above the top of the mast (derrick), do not hoist a rod column with loose tool joints and do not make up, tighten or loosen tool joints while the rod column is being supported by a rod slipping device. If drill rods should slip back into the borehole, do not attempt to break the fall of the rods with your hands or by tensioning the slipping device.
- Most sheaves on exploration drill rigs are stationary with a single part line. Never increase the number of parts of line without first consulting the manufacturer of the drill rig.
- Wire ropes must be properly matched with each sheave - if the rope is too large, the sheave will pinch the wire rope - if the rope is too small, it will groove the sheave. Once the sheave is grooved, it will severely pinch and damage larger sized wire ropes.
- The following procedures and precautions must be understood and implemented for safe use of wire ropes and rigging hardware:
  - Use tool-handling hoists only for vertical lifting of tools (except when angle hole drilling). Do not use tool-handling hoists to pull objects away from the drill rig; however, drills may be moved using the main hoist if the wire rope is spooled through proper sheaves according to the manufacturer's recommendations.
  - When stuck tools or similar loads cannot be raised with a hoist, disconnect the hoist line and connect the stuck tools directly to the feed mechanism of the

drill. Do not use hydraulic leveling jacks for added pull to the hoist line or the feed mechanism of the drill.

- When attempting to pull out a mired down vehicle or drill rig carrier, only use a winch on the front or rear of the vehicle and stay as far away as possible from the wire rope. Do not attempt to use tool hoists to pull out a mired down vehicle or drill rig carrier.
- Minimize shock loading of a wire rope - apply loads smoothly and steadily.
- Avoid sudden loading in cold weather.
- Never use frozen ropes.
- Protect wire rope from sharp corners or edges.
- Replace faulty guides and rollers.
- Replace damaged safety latches on safety hooks before using.
- Know the safe working load of the equipment and tackle being used. Never exceed this limit.
- Inspect and test clutches and brakes of hoists periodically.
- Know and do not exceed the rated capacity of hooks, rings, links, swivels, shackles, and other lifting aids.
- Always wear gloves when handling wire ropes.
- Do not guide wire rope on hoist drums with your hands.
- Following the installation of a new wire rope, first lift a light load to allow the wire rope to adjust.
- Never carry out any hoisting operations when the weather conditions are such that hazards to personnel, the public, or property are created.
- Never leave a load suspended in the air when the hoist is unattended.
- Keep your hands away from hoists, wire rope, hoisting hooks, sheaves and pinch points as slack is being taken up and when the load is being hoisted.
- Never hoist the load over the head, body or feet of any personnel.
- Never use a hoist line to "ride" up the mast (derrick) of a drill rig.
- Replacement wire ropes should conform to the drill rig manufacturer's specifications.

#### 4.3.9.8 Safe Use of Cathead and Rope Hoists

The following safety procedures shall be employed when using a cathead hoist:

- Keep the cathead clean and free of rust and oil and/or grease. Clean the cathead with a wire brush if it becomes rusty.
- Check the cathead periodically, when the engine is not running, for rope wear grooves. Replace the cathead if a rope groove forms to a depth greater than 1/8 inch (3 millimeter).

- Always use a clean, dry, sound rope. A wet or oily rope may "grab" the cathead and cause drill tools or other items to be rapidly hoisted to the top of the mast.
- Should the rope "grab" the cathead or otherwise become tangled in the drum, release the rope and sound an appropriate alarm for all personnel to rapidly back away and stay clear. The operator shall also back away and stay clear. If the rope "grabs" the cathead, and tools are hoisted to the sheaves at the top of the mast, the rope will often break, releasing the tools. If the rope does not break, stay clear of the drill rig until the operator cautiously returns to turn off the drill rig engine and appropriate action is taken to release the tools. The operator shall keep careful watch on the suspended tools and shall quickly back away after turning off the engine.
- The rope shall always be protected from contact with all chemicals. Chemicals can cause deterioration of the rope that may not be visibly detectable.
- Never wrap the rope from the cathead (or any other rope, wire rope or cable on the drill rig) around a hand, wrist, arm, foot, ankle, leg or any other part of your body.
- Always maintain a minimum of 18 inches of clearance between the operating hand and the cathead drum when driving samplers, casing or other tools with the cathead and rope methods. Be aware that the rope advances toward the cathead with each hammer blow as the sampler or other drilling tool advances into the ground.
- Never operate a cathead (or perform any other task around a drill rig) with loose unbuttoned or otherwise unfastened clothing or when wearing gloves with large cuffs or loose straps or lacings.
- Do not use a rope that is any longer than necessary. A rope that is too long can form a ground loop or otherwise become entangled with the operator's legs.
- Do not use more rope wraps than are required to hoist a load.
- Do not leave a cathead unattended with the rope wrapped on the drum.
- Position all other hoist lines to prevent contact with the operating cathead rope.
- When using the cathead and rope for driving or back-driving, make sure that all threaded connections are tight and stay as far away as possible from the hammer impact point.
- The cathead operator must be able to operate the cathead standing on a level surface with good, firm footing conditions without distraction or disturbance.

#### 4.3.9.9 Safe Use of Augers

The following general procedures shall be used when starting a boring with a continuous flight or hollow-stem augers:

- Prepare to start an auger boring with the drill rig level, the clutch or hydraulic rotation control disengaged, the transmission in low gear and the engine running at low RPM.

- Apply an adequate amount of down pressure prior to rotation to seat the auger head below the ground surface.
- Look at the auger head while slowly engaging the clutch or rotation control and starting rotation. Stay clear of the auger.
- Slowly rotate the auger and auger head while continuing to apply down pressure. Keep one hand on the clutch or the rotation control at all times until the auger has penetrated about 1 foot or more below ground surface.
- If the auger head slides out of alignment, disengage the clutch or hydraulic rotation control and repeat the hole starting process.
- An auger guide can facilitate the starting of a straight hole through hard ground or pavement.
- The operator and tool handler shall establish a system of responsibility for the various activities required for auger drilling, such as connecting and disconnecting auger sections, and inserting and removing the auger fork. The operator must assure that the tool handler is well away from the auger column and that the auger fork is removed before starting rotation.
- Only use the manufacturer's recommended method of securing the auger to the power coupling. Do not touch the coupling or the auger with your hands, a wrench or any other tools during rotation.
- Whenever possible, use tool hoists to handle auger sections.
- Never place hands or fingers under the bottom of an auger section when hoisting the auger over other auger sections or other hard surfaces such as the drill rig platform.
- Never allow feet to get under the auger section that is being hoisted.
- When rotating augers, stay clear of the rotating auger and other rotating components of the drill rig. Never reach behind or around a rotating auger for any reason whatsoever.
- Use a long-handled shovel to move auger cuttings away from the auger. Never use your hands or feet to move cuttings away from the auger.
- Do not attempt to remove earth from rotating augers. Augers should be cleaned only when the drill rig is in neutral and the augers are stopped from rotating.

#### 4.3.9.10 Safety During Rotary and Core Drilling

- Rotary drilling tools shall be safety checked prior to drilling:
  - Lubricate and check water swivels and hoisting plugs for "frozen" bearings before use. Use only approved lubrication fluids.
  - Check drill rod chuck jaws periodically and replace when necessary.
  - Check the capacities of hoists and sheaves against the anticipated weight to the drill rod string plus other expected hoisting loads.

- Special precautions for safe rotary or core drilling involve chucking, joint break, hoisting, and lowering of drill rods:
  - Only the operator of the drill rig shall brake or set a manual chuck so that rotation of the chuck will not occur prior to removing the wrench from the chuck.
  - Do not brake drill rods during lowering into the hole with drill rod chuck jaws.
  - Do not hold or lower drill rods into the hole with pipe wrenches.
  - If a string of drill rods are accidentally or inadvertently released into the hole, do not attempt to grab the falling rods with your hands or a wrench.
  - In the event of a plugged bit or other circulation blockage, relieve or bleed down the high pressure in the piping and hose between the pump and the obstruction before breaking the first tool joint.
  - When drill rods are hoisted from the hole, they shall be cleaned for safe handling with a rubber or other suitable rod wiper. Do not use your hands to clean drilling fluids from drill rods.
  - If work must progress over a portable drilling fluid (mud) pit, do not attempt to stand on narrow sides or cross members. The mud pit shall be equipped with rough surfaced, fitted cover panels of adequate strength to hold drill rig personnel.
  - Do not lean unsecured drill rods against the mast. Either provide some method of securing the upper ends of the drill rod sections for safe vertical storage or lay the rods down.

#### 4.3.9.11 Engines and Pumps

The following engine and pump stop devices are as follows:

- For an internal-combustion engine: an ignition or grounding switch
- For a diesel engine: a quick-closing valve or equivalent device which will shut off the air to the air-intake manifold of the engine and prevent entry of gas-laden air, or a means of releasing the engine compression, which will not produce an open flame or spark
- For an electric motor: a suitable switch in the motor circuit, or a switch or stop button in the control circuit, approved for the location in which it is installed

Mud pumps shall be equipped with a pressure-relieving device set to release within the limits of the safe working pressure of the pump. Such devices include direct spring-loaded safety valves, shear-pin safety valves, and rupture disks. There shall be no valve between the pump and its pressure-relieving device. The point of discharge from a pressure-relieving device shall be located where employees are not endangered by the discharge of fluids. Each pump shall be

equipped with bleeder valves. All personnel involved in the operation of the rig shall know the exact location of each stop device.

#### 4.3.9.12 Safety During Travel

The individual who transports a drill rig on and off a drilling site shall:

- Be properly licensed and shall only operate the vehicle according to federal, state, and local regulations.
- Know the traveling height (overhead clearance), width, length and weight of the drill rig with carrier and know the highway and bridge load, width and overhead limits, making sure that these limits are not exceeded and allowing an adequate margin of safety.
- Never move a drill rig, unless the vehicle brakes are in sound working order.
- Allow for mast overhang when cornering or approaching other vehicles or structures.
- Be aware that the canopies of service stations and motels are often too low for a drill rig mast to clear with the mast in the travel position.
- Watch for low hanging electrical lines, particularly at the entrances to drilling sites or restaurants, motels or other commercial sites.
- Never travel on a street, road, highway with the mast (derrick) of the drill rig in the raised or partially raised position. Never travel with the mast raised at any job site, unless the path of travel is short and there are no overhead obstructions of nearby power lines.
- Remove all ignition keys when a drill rig is left unattended.

#### 4.3.9.13 Off-Road Movement

The following safety precautions relating to off-road movement shall be followed:

- Before moving a drill rig, first walk the route of travel, inspecting for depressions, stumps, gullies, ruts, and similar obstacles.
- Always check the brakes of a drill rig carrier before traveling, particularly on rough, uneven or hilly ground.
- Check the complete drive train of a carrier at least weekly for loose or damaged bolts, nuts, studs, shafts, and mountings.
- Discharge all passengers before moving a drill rig on rough or hilly terrain.
- Engage the front axle (for 4 x 4 and 6 x 6 vehicles or carriers) when traveling off highway on hilly terrain.
- Use caution when traveling a side-hill. Conservatively evaluate side-hill capability of drill rigs, because the arbitrary addition of drilling tools may raise the center of

gravity. When possible, travel directly uphill or downhill. Increase tire pressures before traveling in hilly terrain (do not exceed rated tire pressure).

- Attempt to cross obstacles such as small logs and small erosion channels or ditches squarely, not at an angle.
- Use the assistance of someone on the ground as a guide when lateral or overhead clearance is close.
- After the drill rig has been moved to a new drilling site, set all brakes and/or locks and block wheels.
- Never travel off-road with the mast (derrick) of the drill rig in the raised or partially raised position.

#### 4.3.9.14 Tires, Batteries, and Fuel

Tires on the drill rig must be checked daily for safety and during extended travel for loss of air and they must be maintained and/or repaired in a safe manner. If tires are deflated to reduce ground pressure for movement on soft ground, the tires should be reinflated to normal pressures before movement on firm or hilly ground or on streets, roads, and highways. Under-inflated tires are not as stable on firm ground as properly inflated tires. Air pressures shall be maintained for travel on streets, roads, and highways according to the manufacturer's recommendations. During air pressure checks, inspect for:

- Missing or loose wheel lugs
- Objects wedged between dual tires or embedded in the tire casing
- Damaged or poorly fitting rims or rim flanges
- Abnormal or uneven wear and cuts, breaks or tears in the casing

The repair of truck and off-highway tires shall only be made with required special tools following the recommendations of a tire manufacturer's repair manual. If they are split rim tires, repairs shall be performed using an appropriate tire cage device.

Batteries contain strong acid. Use the following precautions when servicing batteries:

- Batteries shall only be serviced in a ventilated area while wearing safety glasses.
- When a battery is removed from a vehicle or service unit, disconnect the battery ground clamp first.
- When installing a battery, connect the battery ground clamp last.
- When charging a battery with a battery charger, turn off the power source to the battery before either connecting or disconnecting charger leads to the battery posts. Loosen cell caps prior to charging to permit the escape of gas.

- Spilled battery acid can burn your skin and damage your eyes. Spilled battery acid shall be immediately flushed off your skin with lots of water. Should battery acid get into someone's eyes, flush immediately with large amounts of water and see a medical physician at once.
- To avoid battery explosions, keep the cells filled with electrolyte, use a flashlight (not an open flame) to check electrolyte levels, and avoid creating sparks around the battery by shorting across a battery terminal. Keep lighted smoking materials and flames away from batteries.

The following special precautions must be taken for handling fuel and refueling the drill rig or carrier:

- Only use the type and quality of fuel recommended by the engine manufacturer.
- Refuel in a well-ventilated area.
- Do not fill fuel tanks while the engine is running. Turn off all electrical switches.
- Do not spill fuel on hot surfaces. Clean any spillage before starting an engine.
- Wipe up spilled fuel with cotton rags or cloths - do not use wool or metallic cloth.
- Keep open lights, lighted smoking materials, and flames or sparking equipment well away from the fueling area.
- Turn off heaters in carrier cabs when refueling the carrier or the drill rig.
- To allow for expansion of the fuel during temperature changes, do not fill portable fuel containers completely full.
- Keep the fuel nozzle in contact with the tank being filled to prevent static sparks from igniting the fuel.
- Do not transport portable fuel containers in the vehicle or carrier cab with personnel.
- Fuel containers and hoses shall remain in contact with a metal surface during travel to prevent the buildup of static charge.

#### 4.3.9.15 Drill Rig Utilization and Alterations

Do not attempt to exceed manufacturer's ratings of speed, force, torque, pressure, flow, and so forth. Only use the drill rig and tools for the purposes which they are intended and designed.

Alterations to a drill rig or drilling tools shall only be made by qualified personnel and only after consultation with the manufacturer.

### 4.3.10 Overhead Electrical Hazards

Overhead power lines may present a hazard to equipment and personnel. To prevent equipment contact with power lines and to prevent arcing, adequate clearance must be maintained. For lines

rated 50 kilovolt (kV) or below, the minimum clearance between the lines and any part of the crane or load will be 10 feet. For lines rated more than 50 kV, the minimum clearance between the lines and any part of the crane or load will be 10 feet plus 0.4 inch for each kV more than 50 kV. TtFW requires a minimum clearance of 15 feet.

### 4.3.11 Excavation Safety

Any excavation or trenching operation that is 4 feet or more in depth will be performed in accordance with EM 385-1-1 and TtFW EHS Procedure 6-3. A TtFW excavation permit must be completed by a competent person before excavation commences and at least each day thereafter. This permit requires daily inspections of the operation and adjacent areas. Specific situations addressed in these inspections are possible cave-ins, indications of failure of protective systems (benching, sloping, or shoring), hazardous atmospheres, and other hazardous conditions. If the competent person finds evidence of any of these situations, exposed employees will be removed from the hazardous area until the necessary precautions have been taken to ensure their safety. In addition to the excavation permit, for work in California, a Cal-OSHA Activity Notification Form for Holders of Annual Excavation Permits must be filed with Cal-OSHA for any excavation 5 feet or greater in depth into which workers will enter. TtFW has an annual permit for excavations in the state of California. Also, Underground Service Alert (Dig Alert), 800-642-2444, must be notified before any excavation work begins regardless of depth. Exploratory techniques, such as "pot-holing" will be performed to ensure that any excavation near utilities can be performed safely. Dust suppression measures may include the use of a compound, which will make the soil less likely to dust or use water. However, work procedures as soil is moved and especially as it is lifted and loaded must be performed in such a way to minimize the generation of dust. For example, loaders dumping soil into a dump truck or a stockpile may have to lower the bucket as close as possible to the truck or stockpile before dumping to reduce the drop height of the soil and, thereby, reduce the amount of dust generated.

The following provides general requirements governing activities in and around excavations and trenches, as well as the requirements for the selection and use of protective systems.

- Surfaces surrounding open trenches and excavations shall have all surface hazards removed.
- All utilities shall be located and cleared prior to initiating digging. Public or facility utility groups shall be used where possible for this purpose. In the absence of either, the ESS shall specify the procedures to be used to clear utilities in consultation with the PESM and PjM. When the excavation is open, utilities shall be supported and protected from damage. Clearance and support methods shall be documented on the daily inspection checklist. EM 385-1-1, Section 25, requires the installation of perimeter protective systems for all open excavations. Class I perimeter protection is the most protective and requires installation of fences and barricades, which would prevent members of the public (people other than workers) from entering or falling

into the excavation. Consult the EM 385-1-1 for the types of protective system required for various situations.

- Where structural ramps are used for egress, they shall be installed in accordance with 29 CFR 1926.651(c)(1).
- Stairways, ladders, or ramps shall be provided as means of egress in all trenches 4 feet or more in depth. Travel distance shall be no more than 25 feet between means of egress.
- Employees exposed to vehicular traffic shall wear traffic vests.
- No employee shall be permitted under loads being lifted or under loads being unloaded from vehicles.
- When vehicles and machinery are operating adjacent to excavations, warning systems such as stop logs or barricades shall be used to prevent vehicles from entering the excavation or trench. In any case, vehicles, equipment, materials, and supplies will never be placed closer than 2 feet from the edge of any excavation. A professional engineer may have to calculate the distances of heavier equipment for placement away from the edge so as to prevent collapse of the excavation wall caused by the weight of the equipment.
- Scaling or barricades shall be used to prevent rock and soils from falling on employees.
- Excavated and loose materials should be kept at least 3 feet from the edge of excavations, but at a minimum of 2 feet from the edge of the excavation in accordance with OSHA requirements.
- Walkways or bridges with standard railing shall be provided where employees cross over excavations or trenches.
- Barriers shall be provided to prevent personnel from inadvertently falling into an excavation. Workers within 2 feet of the edge of the excavation must be protected by fall protection (guardrails or personal protection).

#### 4.3.11.1 Hazardous Atmospheres

Where atmospheres containing less than 19.5 percent oxygen or other types of hazardous atmospheres may exist, the following requirements shall be implemented:

- Atmospheric testing shall be done prior to employees entering excavations 4 feet or greater in depth.
- Testing methods shall be listed on the daily inspection checklist and results documented daily in field logs.
- Control measures such as ventilation and PPE shall be used to control employee exposure to hazardous atmospheres below published exposure limits.

- Ventilation shall be used to control flammable and combustible vapors to below 10 percent of their lower explosive limit.
- Testing shall be repeated as often as necessary to ensure safe levels of airborne contaminants.
- Emergency equipment shall be provided and attended when the potential for a hazardous atmosphere exists. This equipment shall include but not be limited to emergency breathing apparatus, harnesses, lifelines, and basket stretchers. Required equipment will be listed on the daily inspection checklist and reviewed daily.

#### 4.3.11.2 Protection From Water Hazards

When water has collected or is collected in excavations and trenches, the following requirements shall be applied:

- Employees shall not work in excavations in which water has, or is, accumulating without the use of additional protection such as special support systems or water removal.
- Water removal shall be monitored by a competent person.
- Barriers such as ditches and dikes shall be used to divert runoff from excavations and trenches.
- Trenches shall be reinspected prior to re-entry after water accumulation due to heavy rainfall or seepage.

#### 4.3.11.3 Stability of Adjacent Structures

When excavating or trenching near an adjacent structure, the following practices shall be implemented:

- Support systems such as shoring, bracing, or underpinning shall be provided where the stability of buildings, walls, or other structures are endangered by excavation.
- Excavation bases or footings of foundations shall be prohibited unless support systems are used, the excavation is in stable rock, a professional engineer has determined that the structure is sufficiently removed from the site as to not pose a hazard, or a professional engineer determines that the excavation shall not pose a hazard to employees due to the structure.
- Support systems shall be used when it is necessary to undermine sidewalks, pavements, and appurtenant structures.
- Surcharge load sources and adjacent encumbrances shall be listed with their evaluation date on the daily inspection checklist.

#### 4.3.11.4 Daily Inspections

Inspections shall be performed daily on all excavations, adjacent areas, and protective systems before personnel enter the trench. The checklist provided in the EHS procedure or equivalent will be used.

#### 4.3.11.5 Soil Classification

To perform soil classification, the competent person shall use a thumb test, pocket penetrometer, or shear vane to determine the unconfined compressive strength of the soils being excavated. In soils with properties that change (one soil type mixed with another within a given area), several tests may be necessary. When different soil types are present, the overall classification shall be that of the type with the lowest unconfined compressive strength. Classifications shall result in a soil rating of Stable Rock, Type A, Type B, or Type C in accordance with 29 CFR 1926.652, Appendix A. Soil classifications shall be listed on the daily inspection checklist. The soils analysis checklist provided in the EHS procedure or equivalent shall be used for soil classifications.

#### 4.3.11.6 Sloping and Benching

All sloping and benching shall be done in accordance with 29 CFR 1926.652, Appendix B. Selection of the sloping method and evaluation of surface surcharge loads shall be made by a competent person familiar with the requirements contained therein. Sloping and benching methods and specifications shall be listed on the daily inspection checklist.

#### 4.3.11.7 Protective Systems

Protective systems are required on all excavations over 5 feet in depth or in excavations less than 5 feet when examination of the ground by a competent person reveals conditions that may result in cave-ins. Selection and installation of protective systems shall be done in accordance with 29 CFR 1926.652, Appendices C and D, or manufacturers' data for shoring and shielding systems. Selection of a protective system shall be made based upon soil classification and job requirements by a competent person. Protective systems and specifications shall be listed on the daily inspection checklist. Protective systems, as discussed here, refer to protective systems within the excavation itself and not to the perimeter protective systems as mentioned above.

#### 4.3.11.8 Training

Competent persons shall have an adequate combination of experience and training to classify soil types and select protective systems as outlined in 29 CFR 1926.652. Training and experience pertaining to qualification as a competent person shall be documented and include the following:

- General safety practices related to working in or near open excavations
- Inspection requirements and techniques
- Classification of soils in accordance with 29 CFR 1926.652, Appendix A
- Uses, limitations, and specifications of protective systems in accordance with 29 CFR 1926.652

Employees of TtFW, who have received the 48-hour ESS Training class, have had this training as part of this class. Training records shall be maintained in accordance with TtFW EHS Procedure 1-9, Recordkeeping.

## 4.4 RADIATION

Many areas and buildings throughout HPS may have low-level radioactive contamination or debris that has low-level radioactivity. Radioactive materials were used and tested in the past at HPS. The primary purpose of CTO 0072 is the survey and sampling for radioactivity at various locations. Information from previous surveys and from a hazard assessment was used to determine those areas requiring further study or remediation. Work performed in these areas is performed under a Nuclear Regulatory Commission license. It is anticipated that only low-level radioactive materials or sources will be encountered. Survey protocols will be prepared for each work activity and will be incorporated within Work Plans for each activity. A sample of a radiological protection program, a radiological survey protocol, and radiological protection procedures is found in Attachment 3. When a Nuclear Regulatory Commission-licensed subcontractor is used to perform the work, the subcontractor will provide a copy of their radiation protection program and procedures for review by the PESM and a Certified Health Physicist. Their program and procedures will be the basis for all work involving the surveying, sampling, and management of potential or actual radioactive materials.

# 5.0 ACTIVITY HAZARD ANALYSES

Each SHSP will have a section that evaluates the risks and associated precautions for remediation activities associated with the site-specific activities. An AHA is developed for each planned activity and operation occurring in each major phase of work. This AHA identifies the sequence of work, specific hazards anticipated, and the control measures to be implemented to minimize or eliminate each hazard. This AHA is used to augment daily safety meetings intended to heighten safety and hazard awareness on the job. This pre-task briefing will be documented and may be combined with the daily tailgate safety meeting. AHAs are the focal point for safe conduct of work on a project. Since each task is described and evaluated, workers should be better prepared to perform work safely. In summary, the AHA will be covered during the Preparatory Phase Meeting of all definable tasks in the planned work. This will be documented in the Daily CQC Report as having been covered in the preparatory inspection meeting.

The SHSS will discuss the risks and precautions associated with each task identified in the CTO and in the Work Plan. Daily "tailgate" safety meetings are held at the start of each shift. Prior to the day's remediation activity, the safety meeting discusses the potential chemical, physical, and environmental hazards, and preventive safety measures. During a workday, if there are any changes or new conditions, the SHSS will ensure that the AHA is updated and that workers review the amended AHA. Attendance is mandatory for all employees involved in the specific work.

If there are changes required due to changing conditions or requirements, the SHSP may be modified by using the change form attached to the SHSP and by obtaining the approval of the PjM or Site Superintendent, the SHSS, and the PESM.

# 6.0 PERSONAL PROTECTIVE EQUIPMENT

PPE for site workers will be selected and used based upon the existing and potential hazards anticipated and the requirements of 29 CFR, Part 1910.120 (8 CCR, Section 5192). Different levels of personal protection will be provided to workers at the site depending on specific work tasks performed. The selection of PPE requires an evaluation of chemical contaminants, concentrations of these chemical contaminants, and physical hazards that may be encountered.

The initial PPE and action levels for each site activity will be established for each CTO assignment based on available data and defined in the SHSP. As additional testing, monitoring, and background information become available, the SHSS may adjust the action levels and PPE accordingly. The PESM will be consulted for approval to changes in the action levels. The decision to upgrade or downgrade the level of protection allowed in the field will be communicated as appropriate to all site personnel. The decision and justification for the change in level of protection will be recorded in the health and safety logbook.

The SHSP will comply with 29 CFR, Part 1910.132 (8 CCR, Sections 3380 through 3390), which states that all PPE for eyes, face, head, and extremities, protective clothing, respiratory protection devices, and protective shields and barriers shall be provided, used, and maintained in a sanitary and reliable condition. PPE is required wherever it is necessary by reason of hazards from processes or environment, chemical hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation, or physical contact.

Respiratory protection is of primary importance in the protection of employee health since inhalation of air contaminants is a potential major route of exposure. The TtFW respiratory protection program is administered pursuant to the requirements established by 29 CFR, Part 1910.134 (8 CCR, Section 5144). The SHSS is assigned responsibility as the Respirator Program Administrator for the project. Selection, use, and maintenance of PPE at the project shall be in accordance with EHS Procedure 5-1, PPE, and EHS Procedure 5-2, Respiratory Protection. The SHSS may upgrade or downgrade the level of protection based on the hazard anticipated, evaluation of site monitoring data, and established action levels by the SHSP and with the concurrence of the PESM.

The EPA Level categories are as follows:

- ***Level A***: Used when the greatest level of skin, eye, and respiratory protection is needed and consists of a totally encapsulated suit with supplied breathing air.
- ***Level B***: Used when the highest level of respiratory protection is needed but a lesser level (than Level A encapsulated suit) of skin protection is required.

- ***Level C***: Used when criteria for using air-purifying respirators are met and a lesser level of skin protection is required.
- ***Level D***: Used only as a work uniform and in an area without respiratory hazards.

Level D protection is used during site reconnaissance, mobilization, geophysical survey, baseline surveying, and other activities that have no potential for exposure to chemical hazards. PPE for Level D includes:

- Coveralls, cotton and/or disposable
- Boots, leather or rubber, steel toe and shank, non-slip soles
- Rubber overboots or disposable booties (as required)
- Safety glasses or goggles, face shield when handling liquids
- Hard hat
- Gloves as required by task (leather work gloves)
- Hearing protection (as required)

Level C protection is used during Resource Conservation and Recovery Act (RCRA) and non-RCRA soil excavation, temporary storage, loading, backfilling and compaction, decontamination of equipment, and other activities where there is a potential for chemical exposure but where that exposure is below permissible exposure levels with the provided PPE. If air monitoring information dictates that a higher degree of PPE is necessary, levels of protection are increased. PPE for Level C includes:

- Full facepiece air purifying respirator (APR)
- National Institute for Occupational Safety and Health (NIOSH)/Mine Safety and Health Administration (MSHA)-approved air purifying respirator cartridges (approved for use with the specific types of contaminants)
- Emergency escape respirator (optional, depending on the potential for emergency conditions)
- Coveralls (inner), cotton
- Coveralls (outer), chemical-resistant, disposable (Tyvek)
- Gloves (outer), chemical-resistant (nitrile)
- Gloves (inner), cotton or nitrile
- Boots, chemical-resistant, rubber, with steel toe and shank, or leather, with steel toe and shank, with chemically resistant rubber overboot, non-slip soles
- Hard hat
- Hearing protection (optional or as required)

Level B protection is selected and implemented when it is determined through real-time air monitoring and/or personnel sampling that the highest level of respiratory protection is necessary for site personnel. This level of protection is also used when the atmospheric contaminant(s) identified does not meet the selection criteria permitting the use of air purifying respirators or when contaminants are unknown. There is a possibility that this may occur for some CTO-specific work.

PPE for Level B includes:

- Pressure-demand, self-contained breathing apparatus (SCBA) or airline respirator (with attached 5-minute escape bottle)
- Coveralls (inner), cotton
- Coveralls (outer), chemical-resistant, disposable (Tyvek)
- Gloves (outer), chemical-resistant (nitrile)
- Gloves (inner), nitrile
- Boots, chemical-resistant, rubber, with steel toe and shank, or leather, with steel toe and shank, with chemically resistant rubber overboot, non-slip soles
- Hard hat
- Hearing protection (optional or as required).

Subcontractors are responsible for supplying and maintaining their own PPE according to the manufacturers' procedures and guidelines and their own policies and procedures, which must be at least as protective as required by regulations and those procedures described in this Base-Wide Plan.

Most projects usually require the use of either Level D or Level C protection. With each level of protection, there is a degree of variability or modification dependent on the specific tasks and the nature and concentration of contaminants. For example, different tasks on the same site may require gloves of different materials, length, or thickness. Variations of a level of protection will be indicated by a qualifier ("Modified Level D") and specify the modification required. Level A protection, if ever required, will require specific discussion in the SHSP. Level C, B, or A work will always require the implementation of a heat stress monitoring program as described in this plan and in TtFW EHS Procedure 4-6, Temperature Extremes.

For site work under this contract, TtFW or subcontractors will maintain protective equipment on site for use by government visitors as specified in each CTO.

# 7.0 AIR, NOISE, AND OTHER MONITORING

The SHSS will conduct monitoring to ensure that each site worker is adequately protected. Required monitoring will be defined in the SHSP. Site monitoring and sampling may include personal air sampling, real-time air monitoring, perimeter monitoring, radiation monitoring, noise monitoring, and heat stress monitoring.

The SHSS shall have experience using the required monitoring or sampling equipment. The PESM shall ensure that each SHSS is qualified to operate all assigned instruments. The SHSS shall ensure that each piece of equipment is properly maintained and calibrated.

Personal sampling requirements will be defined in the SHSP and will be based on potential airborne hazards and OSHA requirements. Personal sampling methods will be in accordance with NIOSH methods, OSHA instructions, or good industrial hygiene practice when established methods are not available or feasible. A laboratory accredited by the American Industrial Hygiene Association will conduct all laboratory analysis of industrial hygiene samples. Results will be compared to the ACGIH TLVs or OSHA Permissible Exposure Limits, whichever is more stringent. Results will be communicated to employees in accordance with OSHA requirements. All exposure records will be kept in accordance with 29 CFR, Part 1910.20 (8 CCR, Section 3204).

Real-time air monitoring will be used, as appropriate, to identify and quantify airborne levels of hazardous substances and safety and health hazards in order to determine the appropriate level of employee protection needed on site. Real-time monitoring may be necessary for airborne hazards such as flammable vapors, specific target compounds, organic vapors, and dust. Real-time monitoring requirements will be documented in the SHSP and based on the probability of encountering potential contaminants at each site. The PESM will establish action levels and the action required if levels should be reached or exceeded.

All instruments (both real-time and TWA) shall be calibrated according to the manufacturers' recommendations. All equipment shall be calibrated before and after use. A calibration log shall be kept to record all calibrations.

The SHSP may specify the use of colorometric tubes for direct reading of specific contaminants. The details will be discussed and action levels established.

The need for radiation monitoring will be established in the SHSP. Radiation monitoring procedures, action levels, and recordkeeping will be in accordance with 10 CFR, Parts 20 and 29 CFR, Part 1910.1096 (8 CCR, Sections 5075 through 5076).

Noise monitoring and hearing conservation requirements will be defined in the SHSP and implemented in accordance with TtFW EHS Procedure 4-4, Hearing Conservation Program, and 29 CFR, Part 1910.95 (8 CCR, Sections 5095 through 5100).

Heat stress monitoring is used in estimating work loads and establishing work/rest times, based on 1) Wet Bulb Globe Temperature instrumentation and calculations, 2) monitoring physiological conditions and adjusting work/rest periods, or 3) using personnel heat stress monitors. Attachment B of TtFW EHS Procedure EHS 4-6, Temperature Extremes, describes the monitoring procedures in detail.

The SHSS will ensure that all data is documented in logs or logbooks including calibration, types of calibrants used, the manufacturer, model number of instruments used, the date and time of calibration and monitoring events, the area or personnel monitored, the atmospheric conditions and weather, unique site conditions, equipment operating in area, initials of individuals performing the monitoring, and any other information which affects the data or the actions taken based on the data.

# 8.0 SITE CONTROL

The PjM, Site Superintendent, and the SHSS will implement site control measures at each site. These measures will consist of general site control and specific work location site control. Site control measures are specified in the SHSP for each CTO or task.

General site control measures pertain to the overall site and may include the use of security guards, perimeter fencing, sirens, posting of warning signs, and illumination. These control measures are geared toward visitors and the general public. The Site Superintendent and the SHSS implement control measures as necessary.

Location-specific control measures are designed to control contamination and worker entrance and exit from individual work areas. Prior to the commencement of any on-site work, controlled zones of activity will be established by the SHSS. No person will be allowed on the site without a briefing regarding the hazards of the site. This briefing must be documented and signed by the person receiving the briefing. This will reduce the spread of contamination to off-site areas and protect the health and safety of workers. The controlled zones will be included in one of the following categories: 1) exclusion zone—where contamination does or could occur, 2) contamination reduction zone—where decontamination will occur, and 3) support zone—clean zone outside the contamination reduction zone. Each work zone will be clearly identified and delineated by cones, rope, fences, signs, or barricades. The SHSS will maintain a site entry log for each site that documents each person entering a work zone. The logs will be kept in the project files.

## 8.1 EXCLUSION ZONE

The exclusion zone may include all areas within the boundaries of a contaminated work area or merely the areas immediately surrounding the site of intrusive activity. Access points are provided to the exclusion zone. During activities where the possibility of airborne contaminants being carried outside the exclusion zone exists, the exclusion zone will be expanded to include areas of possible contamination. Only designated project team members and authorized government agency personnel shall be allowed in the exclusion zone. All personnel entering the exclusion zone must wear the appropriate level of protection designated for the work area. Personnel must also meet medical surveillance requirements, training requirements, and respirator fit test requirements. All personnel exiting the exclusion zone must be fully decontaminated in the contamination reduction zone.

## 8.2 CONTAMINATION REDUCTION ZONE

All personnel and equipment that may have been contaminated in the exclusion zone will be subject to decontamination in the contamination reduction zone. Temporary or field decontamination stations for personnel and equipment will also be located in the contamination reduction zone as needed. The contamination reduction zone is intended to be a buffer between the exclusion zone and the support zone and will be designed to prevent the transfer of contaminants from the exclusion zone to the support zone and off site. Within this zone is usually located a Contamination Reduction Corridor (CRC). In the CRC, workers will find decontamination equipment, supplies, and stations.

### 8.2.1 Decontamination Procedures

Personal hygiene practices for field personnel will be described in the SHSP. At a minimum, site workers will be provided with adequate restroom and hand washing facilities and be required to wash exposed areas of the skin (hands and face) upon exiting potentially contaminated areas. Smoking, eating, or drinking will not be allowed in exclusion zone or contamination reduction zone work areas.

The SHSS is responsible for the functional activities of the decontamination facilities and shower trailer if one is required on the site. The SHSS will train site personnel in the steps used for decontamination. The SHSS will periodically inspect for compliance with decontamination procedures and correct any deficiencies.

Separate areas will be designated for equipment decontamination and personnel decontamination. These areas will be separated to minimize contamination of the personnel in the contamination reduction zone by overspray from equipment decontamination.

### 8.2.2 Personnel Decontamination

Personnel departing the exclusion zone are required to proceed through a decontamination line. The following decontamination procedure is an example and will be modified to meet site-specific requirements in the SHSP:

- **Facility 1**—Segregated Equipment Drop: Drop equipment onto plastic liner or shelf.
- **Facility 2**—Boot Cover Wash/Rinse and Removal: Wash and rinse outer boot covers with detergent and water. Remove boot covers and discard into proper container for disposal.
- **Facility 3**—Boot Wash/Rinse, Outer Suit Wash/Rinse and Removal: Wash and rinse protective suits. Wash and rinse safety boots. Remove and discard outer suit and place into disposal containers.
- **Facility 4**—Outer Glove Wash/Rinse and Removal: Wash and rinse outer gloves. Remove and discard into disposal container, leaving inner gloves on.

- **Facility 5**—Respirator Removal: Decontaminate, remove, and sanitize respirator and backpack assembly. Place on the table.
- **Facility 6**—Remove Boots and Inner Gloves: Remove boots, then inner gloves and discard inner gloves.
- **Facility 7**—Field Wash: Wash hands and face with water. At shift's end, personnel are then required to enter the decontamination trailer and shower thoroughly (if a trailer and shower are required on the site).

In case of an emergency, gross decontamination procedures will be implemented and the person will be transported to the nearest medical facility immediately at the direction of the SHSS according to the Site Emergency Response Plan (reference Section 12.0). The medical facility will be informed that the injured person is on the way, and has not been fully decontaminated. The medical facilities will be notified of the potential chemicals present and of the exposure-prevention measures that can be used while treating the victim.

A commercial vendor may launder reusable protective clothing (cotton overalls). If the coveralls are contaminated with a hazardous waste, the vendor will be notified of the type of waste.

### 8.2.3 Equipment Decontamination

Heavy equipment, PPE, monitoring equipment, and sampling equipment may require decontamination. Procedures may be modified based on actual site conditions or CTO requirements. Depending on the nature of the contaminant, seats and flooring of equipment and vehicles entering an exclusion zone may need to be covered with disposable plastic such as polyethylene.

Decontamination of heavy equipment (including under carriage, chassis, and cab) will be performed using a high-pressure washer sprayer, and/or steam cleaner and appropriate biodegradable solvents. All equipment will be decontaminated on a pre-constructed decontamination pad designed to collect and store washings. The equipment will first be sprayed and scrubbed with water (and a low-sudsing detergent as required). Secondly, the equipment will be rinsed with water. If persistent contamination exists after cleaning based on visual assessment, other cleaning methods may be necessary. Air filters on equipment used in the exclusion zone will be removed and disposed with the materials used for decontamination if warranted. Depending on the contaminants, a simple scraping and brushing off of the equipment may be acceptable.

Outer PPE (such as protective suits, boot covers, and outer gloves) will be washed and rinsed with trisodium phosphate and water. These items will all be discarded at the end of the day. If they have become grossly contaminated during work operations, they will be changed as necessary during the day. Respirators will be sanitized by rinsing in a germicidal rinse followed by a clean water rinse, then air-drying in a clean area.

Each person will be responsible for the gross decontamination of their own respirators at the end of each shift. A thoroughly trained SHSS will perform respirator maintenance.

Reasonable precautions will be taken to minimize monitoring equipment contamination. Decontamination will be accomplished using materials that will not damage the instrument(s). Delicate air monitoring and surveying equipment will be wiped off with alcohol or soap and water and protected from contamination when in use.

Sampling equipment used for chemical tests will be cleaned following procedures specified in the Sampling Analysis Plan.

If decontamination pads are used, they will be constructed to facilitate containment and collection of all potentially contaminated water and decontamination fluids. The waste liquids will be transferred to appropriate drums, holding facilities, or waste systems. All PPE wastes generated will be bagged, labeled, and stored for off-site disposal or incorporation into other waste materials. TtFW will store waste in a manner and in an area designated by the facility. In no case will storage exceed 90 days from the start date of accumulation of the waste. Some facilities require that storage not exceed a period of time less than 90 days (45 days). Each PjM will ensure that the specific requirements of the facility are followed.

## 8.3 SUPPORT ZONE

The support zone will be arranged considering accessibility, utility availability, wind direction, and line-of-sight to work. Included in this area will be the main office trailer, administration area, vehicle parking, security, toilets, water, electricity, and a break/lunch area. The support zone will be outside the contamination reduction zone and will be the area where support workers will provide assistance to workers inside the exclusion zone and contamination reduction zone. The support zone normally will begin at the exit from the decontamination line. Only clean or appropriately containerized equipment, material or personnel can enter the support zone from the contamination reduction zone.

# 9.0 MEDICAL SURVEILLANCE PROCEDURES

TtFW requires that site workers participate in a medical surveillance program that meets the requirements of 29 CFR, Part 1910.120(f) (8 CCR, Section 5192). The medical surveillance program, managed by the TtFW medical consultant, shall be instituted for the following employees:

- All employees who are or may be exposed to hazardous substances or health hazards at or above the permissible exposure limits or, if there is no permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year.
- All employees who wear a respirator for 30 days or more a year or as required by 29 CFR, Part 1910.134 (8 CCR, Section 5144).
- All employees who are injured, become ill, or develop signs or symptoms due to possible overexposure involving hazardous substances or health hazards from an emergency response or hazardous waste operation.

## 9.1 BASELINE PHYSICAL EXAMINATION PROTOCOL

All employees who are expected to participate in on-site activities where they are potentially exposed to health or safety hazards and/or will wear respiratory protection shall be required to complete a baseline physical examination. The contents of the baseline physical examination are outlined as follows:

A. A completed medical, occupational, and smoking history questionnaire with an emphasis on the following systems: nervous, skin, lung, blood forming, cardiovascular, gastrointestinal, reproductive, as well as ears, nose, and throat. The examinee is required to fast for 8 hours, abstain from alcohol for 3 days before this examination, and avoid high noise exposure for 14 hours before the examination.

B. A complete physical exam, including the following, at a minimum:

1. Height, weight, temperature, pulse, respiration, and blood pressure
2. Head, nose, and throat
3. Eyes (Snellen)
4. Ears (with audiometric testing in accordance with 29 CFR 1910.95)
5. Chest (heart and lungs)
6. Peripheral vascular system
7. Abdomen (liver, spleen, kidney)

8. Musculoskeletal system
9. Genitourinary system
10. Nervous system

C. Completed tests, including at least the following, at a minimum:

1. Complete blood counts and chemistries including the following:

   a. White blood cell, differential cell, and platelet counts
   b. Hemoglobin and/or hematocrit
   c. Albumin, globulin, total protein, and total bilirubin
   d. Serum glutamic oxalacetic transaminase and serum glutamic-pyruvic transaminase
   e. Lactic dehydrogenase
   f. Alkaline phosphatase and Gamma Glutamine Trans Peptidase
   g. Calcium
   h. Phosphorous
   i. Uric acid
   j. Creatinine
   k. Urea nitrogen
   l. Cholesterol and triglycerides
   m. Glucose

2. Urinalysis (clean catch), including the following:

   a. Color and character
   b. Specific gravity
   c. pH
   d. Protein
   e. Acetone
   f. Glucose
   g. Microscopic examination

3. Chest x-ray (14- by 17-inch post-anterior and lateral performed for the baseline exam).

4. Pulmonary function test to include, at a minimum, the following:

   a. Forced Vital Capacity (FVC)

   b. Forced Expiratory Volume, one second (FEV10)

   c. The FEV10 FVC ratio

   d. A minimum of three good tracings

5. 12-lead resting echocardiogram

## 9.2 MEDICAL CLEARANCE

All workers who must enter exclusion zones or who meet the criteria listed above must provide the SHSS with a written opinion from a licensed physician attesting to the employee's fitness for duty at a hazardous waste site. A physician's written opinion of the employee's ability to wear a respirator will also be required when there is reasonable possibility that a respirator may be required for site work. The physician's written opinion must be dated within the previous 12-month period, or an alternate time period as determined by the physician, for continued work. Additional medical surveillance requirements specific to the site or site contaminants may be required and will be defined in the SHSP. For HPS, the PESM in consultation with the TtFW medical consultant has added additional surveillance requirements to include lead, mercury, cadmium and arsenic. At the time of the first physical examination or when an employee is first assigned to projects at HPS, a baseline level for these metals will be obtained.

## 9.3 RECORDKEEPING

The SHSS will maintain a file for each person on site. This file will have a copy of the physician's statement of employee's fitness for duty, the employee's ability to wear a respirator and if there are any work restrictions. The SHSS will ensure that the employee and project supervisors comply with medical work restrictions, if any. The SHSS will also ask each employee to complete a form to indicate any known allergies, prescription medications, and any other medical information that will allow the SHSS to respond to any medical emergency in an appropriate manner. Personnel will notify the SHSS regarding any medications, including over-the-counter, they are using on each day of work. The SHSS in consultation with the PESM and/or a medical consultant will determine if any medications may have an effect on a worker that would impair the ability of the worker to perform work safely. At no time will the SHSS maintain the copy of any actual medical records. These records are maintained by the TtFW medical consultant.

# 10.0 SAFETY CONSIDERATIONS

All workers must comply with the TtFW Project Rules Handbook, Volume I and Volume II. The following are some of these rules:

The following practices will be expressly forbidden during field operations:

- Entrance onto the site or into designated restricted area(s) without formal authorization, compliance with medical monitoring and training requirements, and/or compliance with this SHSP.
- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material in any area designated as contaminated.
- Approach or entries into areas or spaces where toxic or explosive concentrations of gases, vapors, or dusts exist without prior approval of the SHSS and/or use of PPE.
- Facial hair, which interferes with the satisfactory fit of the mask-to-face seal of respirators, is prohibited for personnel required to wear respiratory protection equipment.
- The use/wearing of personal stereo headphones. Their use may preclude reception of audible warning signals and/or hazard communication. Also, cell phones cannot be used during work hours unless an employee is on break or the cell phone is used only for job-related purposes. Cell phones will not be used at any time workers are driving or operating any equipment or using any tools or mechanical devices.

The following practices are required:

- Personnel and equipment in the contaminated area will be minimized, consistent with effective site operations.
- Equipment shall be bonded and grounded, spark-proof and explosion resistant, as appropriate to minimize or prevent the ignition or flammable materials in the work zone.
- A minimum of two employees, in constant communication (either visual or voice) with each other, will be required to perform any work within the exclusion zone.

## 10.1 VEHICLE AND EQUIPMENT OPERATIONS

Prior to the use of all vehicles and equipment, operators will conduct a safety inspection and record the findings in the Safety Inspection Equipment Checklist. The form is provided in Attachment 1. Dust suppressants will be used to the extent possible for controlling airborne dust generation to the extent possible. In addition, vehicular traffic speed on non-paved roads will be restricted to 15 miles per hour. Motor vehicles and material handling equipment assigned to this

site shall conform to the requirements of 29 CFR, Parts 1926.601, and 1926.602 (8 CCR, Sections 1590 through 1596). Crews using personnel transport vehicles to and from the worksite shall use the vehicle's safety belts. Drivers of vehicles shall be responsible for passenger use of the safety belts. Personnel are not allowed to ride in the bed of pickup trucks, unless there is an approved restraint system installed and used. The Site Superintendent is responsible for maintaining a clean jobsite, free from hazards, and for providing safe access and egress from the site. Traffic cones and/or high-visibility barrier tape will be used, where appropriate, for traffic control into/out of hazardous or restricted areas. Personnel will wear reflective, high-visibility safety vests or clothing whenever working in and around vehicles and on all roads and on all jobsites.

Other requirements include the following:

- Whenever the operator leaves the operator's position, the equipment will be turned off, unless the equipment must be kept running to perform required maintenance or safety inspection. (In which case, the operator will ensure that the equipment cannot move by placing equipment in "park', by setting the emergency brake or another type of brake, or by placing blades or pans to the ground or any other manufacturer-recommended method to keep the vehicle from moving.)
- Blades and buckets on heavy equipment will be lowered during transport. Blades and buckets will be placed on the ground whenever the operator leaves the machine.
- Construction equipment (heavy equipment) has the right-of-way in field activities.
- All heavy equipment will have a reverse signal alarm (90 dBA) that operates automatically with backward movement.
- All equipment will have brakes and brake lights. Equipment operated in hours of darkness must have operating headlights.
- Personnel will not ride on or be on any equipment while it is in motion, unless there is a seat or stand designed for a person to occupy that has restraints such as approved seatbelts.
- Seatbelts and restraints will be used at all times when any equipment is in motion.

## 10.2 ADDITIONAL SAFETY CONSIDERATIONS

The following is a list of precautions to minimize the possibility of injury-related accidents from occurring during field operations.

### 10.2.1 General Information

- Be your brother's keeper. Consider what you do in terms of the hazard it may create for others.
- Ask the SHSS if you do not know how or are in doubts as to the safe way of doing your job.

- No running at any time, except in extreme emergencies.
- Throwing of any object at personnel or equipment is prohibited.
- Minimum requirements on construction sites and in shop are long pants, a shirt with the shoulders covered, and good work shoes. Torn, ragged, or frayed items should not be worn because they can catch on obstructions or machine parts, or otherwise cause you to trip or fall.
- Know where emergency exits are, and how to get to them. Do not block them with material or equipment.

### 10.2.2 Housekeeping

- Clean work areas and storage areas encourage better incident prevention, and make the work easier to do.
- Dispose of trash and scrap in proper containers. This includes lunch papers, soft drink cans, banding straps, wood, rags, paper cups, and so forth.
- Keep tools, material, and equipment stored in an orderly manner, and in their proper places. This prevents unnecessary damage and helps you to find them when you need them.
- Keep stored material, scrap, and other tripping hazards out of roads and walkways and away from emergency equipment. If it is in a walkway and it is not moving, it does not belong there.
- Cords, cables, and hoses crossing roads or walkways are to be covered to prevent tripping or damage, or are to be supported overhead, at least 7 feet above walkways, 14 feet above roads.

### 10.2.3 Fire Prevention

- Control "open flame" tools and equipment.
- Protect nearby combustible materials from heat, flames, sparks, and slag by moving or covering them.
- Keep flammables in closed containers. Use safety cans.
- All site workers will have training on the use of portable fire extinguishers.

### 10.2.4 Personal Protective Equipment

- **Head** – Hard hats are required at all times on construction sites. They are also required at other locations where overhead hazards exist. Bump hats are not permitted.
- **Eyes and Face** – Spectacle type safety glasses are required when hitting steel on steel, grinding, drilling, sawing, or vibrating concrete, or so forth, or when working near someone else who is creating flying particles.

- **Boots** – At a minimum, workers will wear steel-toe boots (not shoes, boots must be at least up to ankle, with steel shank and non-slip soles. They must be constructed or leather or other chemically resistive material. Suede and cloth are not acceptable.
- **Safety Vests** – For the protection of workers, and to make workers more visible, most safety plans require that workers wear brightly colored safety vests. Workers working near roads or other places where there is vehicular traffic must wear safety orange or lime green vests as required by code. During hours of darkness, these vests must have reflective tape.
- **Fall Protection** – Safety harnesses and a fall restraint system, such as lanyards, attached to an approved support point are required when working from any support or surface where the possibility of falls exists, or where guardrails are not installed. Tie off to a solid, approved support. Tie off as short as possible allowing no more than 36 inches for fall.

### 10.2.5 Hand Tools

- Every tool is designed for a specific use. Do not misuse. Inspect daily for defects.
- Keep tools in proper working condition - clean, sharp, oiled, dressed, and adjusted.
- Mushroomed chisel and drills cause dangerous flying objects. Keep them dressed.
- Never hit hardened steel with hardened steel, such as hitting a hatchet with a hammer.
- Do not use "cheaters" to increase capacity. Get a bigger sized tool.
- Carry tools in proper sheath, belt bag, or box. Points down.
- Do not carry pointed or sharp tools in any pockets.
- Eye protection is required for protection from flying particles.
- Do not use damaged tools, mark them and tag them as out of service. Give those tools to the Site Superintendent or SHSS.

### 10.2.6 Power Tools

- Know how to shut it off before turning it on. No locked "on" switches on hand-held power tools.
- Eye protection is required for protection from flying particles.
- Power-activated tools shall be inspected daily before use for proper operation of their safety devices. You must be authorized by your foreman to operate this equipment.
- All power tools designed to accommodate guards will have guards installed and functioning prior to use.
- Power supply must be properly attached to tool and to source. Electric tools must be grounded (or "double insulated").
- Check area for other people before starting tool. Warn people nearby.

- Be prepared for jamming of rotating tools. Have good footing, good balance, and watch out for nearby obstructions. Check yourself for loose clothing.
- Shut off and bleed down air hose before disconnecting air tools. Never point an air hose toward another person or yourself.
- Power tools must be GFCI-protected or double-insulated.
- Avoid using power tools in wet locations (air-powered tools may be used).
- Protect all cords and plugs from damage. Ensure that the power cord is well away from the operating portion of the power tool.
- All power tools must be turned off before disconnecting from power source. If a circuit breaker is tripped or the tool stops operating, turn off the power switch before disconnecting the power source.
- Disconnect power cords from source before coiling.
- Refer to Section 4.3.5 regarding the use of extension cords.
- Unplug electric cords.
- Store in safe place when not in use. Protect from weather, dirt, and water.

### 10.2.7 Material Hoists

- Do not use for hoisting people.
- Secure material to prevent it from shifting.
- Use tag lines
- Ensure that rigging is performed by a person competent in rigging techniques.
- Inspect all rigging before use.

### 10.2.8 Crane

- General
  - Know the crane capacity and the weight to be lifted before lifting.
  - Be sure air space and walkway are clear before moving bridge or trolley.
  - Inspect all rigging before use.
  - A competent person must inspect all rigging and the crane before use and certify that crane is safe and positioned properly.
  - A positive acting device will be used to prevent contact between the load block or overhaul ball and the boom tip (anti-two blocking device), or a system will be used that deactivates the hoisting action before damage occurs in the event of a two-blocking situation.

- Mobile
  - Solid footing. Use outriggers with rubber-tired cranes.
  - Barricade area of swing of counterweight.
  - Keep boom, lines, and loads at least 15 feet away from electric power lines. Minimum distance increases above 50,000 volts. Power lines must be de-energized to work closer than the minimum distance.
  - The operator shall avoid swinging loads over workmen's heads. Have only one signalman at any one time.
  - Equipment shall be inspected before each use, and all deficiencies corrected before further use.

### 10.2.9 Forklifts

- You must be authorized by your supervisor before operating this equipment.
- Keep forks spread as far apart as possible. Check stability of load before moving it.
- Look in direction of travel before moving and during moving. Watch out for overhead hazards.
- Back down grades when carrying a load.
- No riders allowed, unless a passenger seat is provided.
- Forks are not to be used as an elevator or as a work platform.
- Lower forks all the way down before leaving the equipment.
- Do not drive along the edge of raised docks, platforms, or ramps.
- In California, operating rules must be posted.

### 10.2.10 Mechanical Material Handling

- Know the weight of the load to be moved.
- Know the capacity of the equipment to be used to move the load.
- Use tag lines to control the load. Keep tag line free of your body, and free of obstructions during movement of the load.

### 10.2.11 Manual Material Handling

- Leg muscles are stronger than back muscles. Lift with your legs not your back. Bend knees, keep back straight, tighten abdomen, and using legs, make a smooth controlled lift.
- Plan before you lift - consider weight, size, shape, path of travel, and set down location. Get help if necessary.
- Protect your hands and fingers from rough edges, sharp corners, and metal straps. Keep hands and fingers out of pinch points between the load and other objects.

### 10.2.12 Overhead Work

- No one is to be unprotected under overhead work.
- Erect barricades, signs, or other devices to warn people of the work overhead. Respect the barricades or signs put up by others.
- Covered walkways are needed where people must pass under overhead work.

### 10.2.13 Portable Ladders

- General - All Portable Ladders
  - Inspect for defects. When defects are found, the ladder is to be withdrawn immediately from use. Set ladder feet on solid foundation.
  - Only one person is allowed on a ladder at one time.
  - Use ladders for climbing -not for material skids, walkways, or workbenches.
  - Face the ladder while climbing up or down, and while working from it. Use safety harness or fall protection when falls are possible.
  - Both hands are needed for climbing. Use a hand line for material.
  - No metal ladders are to be used.
  - Store safely to prevent damage from vehicles, materials, and so forth.
- Straight and Extension Ladders
  - Correct slope of ladder is 1:4.
  - Secure ladder from slipping. Non-slip feet on bottom, and tie off with rope at top.
  - Extend ladder 3 feet above top landing where ladder is to be used for access to the landing.
  - Extension ladders cannot exceed 30 feet.
  - Do not take extension ladders apart to get two ladders.
  - Keep hands off rungs while extending or lowering extension section. Be sure latches are in place before climbing.
- Stepladders
  - Open fully. Lock spreaders. Do not use as a straight ladder.
  - Do not stand or step on top platform.
  - Keep loose tools off steps and top platform.
  - Tie off stepladder if longer than 12 feet.
  - Stepladders cannot exceed 20 feet in height.

### 10.2.14 Compressed Gas Cylinders

- Always keep cylinders upright. Tie off vertically with strong wire, rope or chain, or keep chained in cylinder cart.

- Do not drop or roll the cylinders.
- Use a rack for lifting cylinders to and from upper elevations. Never lift a cylinder by the control valve or a valve cover.
- Always replace valve covers when gauges are removed. Valve covers must be placed on all cylinders before they are moved.
- Store oxygen cylinders 20 feet away from other cylinders, or separate by a solid approved divider. Do not store any cylinders inside a building.
- Keep oil and grease away from oxygen valves.
- Cylinders are to be kept at a safe distance or shielded from welding and cutting operations. They are not to be placed where they can contact an electric circuit.
- Acetylene cylinders must always be stored upright.
- Use only regulators specifically approved for the type of gas in the cylinder (read the front of the gauges for this information). Never modify regulators or use adapters.

### 10.2.15 Welding and Burning

- Electric
  - Keep leads out of walkways.
  - Shield arcs to protect others from direct arc rays
  - Wear proper shade number of protective lenses (welding goggles or helmets).
  - Remove rod from electrode holder before laying it down. Put rod butts in a container, not on the floor.
  - Proper grounding from work to machine is a must.
  - Turn off machine at end of shift.
- Gas
  - Keep hoses out of walkways.
  - Wear proper shade number of protective lenses (welding goggles or helmet)
  - Check area sides and below for possible fire hazards.
  - Remove gauges at end of shift and replace cap on cylinder. Use toolboxes to store hose and ventilate gauges.
  - Use soapy water when checking for leaks.
  - Before using fuel gas cylinders:
    - Always crack cylinder valve before connecting gauges to clean dirt.
    - Open cylinder valve slowly and leave wrench in position while cylinder is in use.
    - A regulator shall always be used on fuel gas cylinders.
    - The cylinder valve shall always be closed before removing regulator.

- When fuel gas cylinders connected to gauges have a leak, it will be repaired or removed from service and tray away from the work area.

### 10.2.16 Electricity

- Refer to Section 4.3.5 for additional details on electrical safety.
- All electrical work will be performed by qualified persons familiar with the NEC and other applicable codes.
- Temporary lighting circuits require guards over the bulbs. Metal guards must be grounded.
- Keep extension cords out of water and at least 7 feet above walkways.
- Disconnect switches must be labeled to show the equipment or service they feed. Check before operating.
- Always shut down electrical equipment before servicing, repairing, or investigating questionable function.

### 10.2.17 Decontamination

- Personnel
  - Do not walk through areas of obvious or known contamination.
  - Do not handle or touch contaminated materials directly.
  - Make sure PPE is free of cuts or tears prior to donning.
  - Fasten all closures on suits, covering with tape, if necessary.
  - Particular care should be taken to protect from any skin injuries.
  - Do not carry cigarettes or gum into contaminated areas.
- Heavy Equipment
  - Take care to limit the amount of contamination that comes in contact with heavy equipment.
  - If contaminated tools are to be placed on non-contaminated equipment for transport to the decontamination pad, use plastic to keep the equipment clean.

### 10.2.18 Illumination

All work on site when performed outdoors must be performed during daylight hours only (½ hour after sunrise to ½ hour before sunset). If work must be performed during hours of darkness or inside buildings, the project will ensure that additional lighting is provided to meet the requirements of 29 CFR, Part 1910.120 (8 CCR, Section 5192).

## 10.3 ERGONOMIC CONSIDERATIONS

Routine activities at the project may involve tasks that, by their nature, may subject personnel to unexpected ergonomic stresses. Examples of ergonomic stresses include:

- Muscular sprains and strains
- Musculoskeletal trauma from impacts or vibrations
- Fatigue due to extended work schedules

Caution and workload awareness should be exercised by all site personnel during project activities. Tasks which involve manual manipulation of sampling devices, chemical storage drums, shoveling, and/or prolonged exposure to vibrating mechanical equipment should be monitored by the individuals involved with them to preclude the adverse effects of ergonomic stress. Tasks should be rotated among the workers to minimize the effects of repetitive trauma.

# 11.0 DISPOSAL PROCEDURES

The Waste Management Plan describes the handling of wastes from the project site and the management of all decontamination liquids and disposable clothing and supplies that have come in contact with contaminated materials. All disposable PPE will be treated as contaminated waste and disposed of properly. Contaminated clothing will be placed in a drum lined with a polyethylene bag. Wastewater generated on site will be stored until ready for testing and disposal. Temporary waste storage areas will be set up by each exclusion zone during the work day. This waste will then be moved to a main storage area until ready for disposal, if required by environmental personnel. All waste containers will be properly labeled and stored as consistent with regulatory requirements. Contents of the containers will be sampled by trained sample technicians and sent to a laboratory to determine regulatory permitted disposal methods. Decontamination water will be contained and captured using submersible pumps and/or vacuum units. TtFW will arrange for the proper disposal of all decontamination fluids, contaminated debris, soil and other waste per contract requirements. In no case will accumulation be allowed to exceed 90 days from the date that the accumulation started. TtFW has policies and procedures that require that all disposal is managed by firms that have been pre-approved by an internal review process and by the DON.

# 12.0 EMERGENCY RESPONSE PLAN

There are numerous emergency services nearby in the civilian community. This plan describes response activities as they apply to HPS. Site-specific response procedures, if any different, will be discussed in the SHSP. Certain information will always be repeated in every SHSP to ensure that the information is readily available and "on top." For example, every SHSP will have a table that lists all the emergency contact numbers and the map to the nearest medical facilities.

## 12.1 RESPONSIBILITIES

The Site Superintendent or PjM, is the primary emergency coordinator for the project. In the absence of either or both the Site Superintendent and the PjM, the SHSS is the emergency coordinator. The emergency coordinator will take charge and determine, direct, and delegate personnel and resources to manage the emergency. Key responsibilities of the emergency coordinator are to:

- Initiate evacuation, if needed.
- Initiate emergency response agency notification.
- Evaluate and assess emergency situation to ensure that response activities are commensurate with the level of the emergency and, as discussed in this plan, are implemented.
- Interface and coordinate with outside agencies responding to on-site emergencies.

## 12.2 COMMUNICATIONS

Personnel shall maintain verbal communication. The following communication systems will be available during site activities:

- Cellular telephone or access to a land phone for emergency purposes.
- Hand-held radios, as needed.
- Compressed air horn (signals emergency evacuation only) at the site.
- Hand signals, if used, will be diagrammed and posted.
- Posted location of evacuation assembly area(s).
- Posted route to the nearest hospital for the project site.
- Posted emergency phone numbers.

## 12.3 ACCIDENT/INCIDENT REPORT

After the emergency event is over or during the course of the emergency when possible, the SHSS will notify the PESM by telephone. Should an accident or incident occur, the Site Superintendent or PjM and the SHSS will immediately investigate the cause, notify the PESM, and promptly complete the following:

- ***TtFW Incident Report Form***. Details of the incident shall be documented within 24 hours and copies of the report forwarded to the DON RPM and the PESM. Reports of serious incidents will also be faxed to the PM by the Site Superintendent or PjM.
- ***Incident Investigation Report***. The Incident Investigation Report will have the same distribution as the Incident Report Form within 3 days of the incident.

Any recommended additional hazard control measures must be discussed with the Site Superintendent, the SHSS, and the PESM and meet their approval, prior to implementation. Any occupational injuries and illnesses will be recorded, if applicable, on an OSHA Form No. 300. The SHSS shall report immediately by telephone or telegraph to the nearest District Office of the Division of Occupational Safety and Health (Cal-OSHA) any serious injury or illness, or death, of an employee occurring in a place of employment or in connection with any employment. Immediately means as soon as practically possible but not longer than 8 hours. Records of all site accidents and first aid treatments will be maintained by the SHSS.

## 12.4 PRE-EMERGENCY PLANNING

Prior to performing any work, the Site Superintendent or PjM and the SHSS will verify all emergency action plans by ensuring that planned support facilities are available and that emergency contact numbers are valid. As work proceeds, the SHSS will continue to ensure that plans specified in this section can be implemented at all times. Furthermore, the SHSS will constantly ensure that plans are modified as necessary to accommodate changes. The SHSS will coordinate all changes with the PESM. Upon arrival at the site, the Site Superintendent will ensure that all personnel know the system for communication of emergency situations and how to use a radio or nearby phone to summon emergency assistance. A vehicle must be available to transport personnel to safe locations or to hospitals. All personnel on this project will know how to use a portable fire extinguisher. All personnel will know the location of all emergency equipment and supplies. The SHSS will ensure that emergency equipment is available in the work areas as specified by site-specific plans and that the equipment is inspected as required by regulations and TtFW policies:

- Fire extinguishers – monthly, annual refill and servicing, 7-year hydrotest
- First aid kits – monthly

- Eyewashes – weekly, if preservative is used, eyewash water may be changed every 4 months; otherwise, water must be changed weekly. Only potable water may be used for eyewashes.

## 12.5 EMERGENCY MEDICAL TREATMENT

The following procedures should be observed if an accident with injury occurs:

### 12.5.1 First Aid

Only qualified personnel shall provide first aid and stabilize an individual needing assistance. Life support techniques such as CPR and treatment of life threatening problems such as airway obstruction and shock will be given top priority. At least two persons certified in first aid techniques and CPR will be on each work site at all times; TtFW EHS Procedure 4-1, Bloodborne Pathogens, will be followed when first aid/CPR are administered. The SHSS will be current in first aid and CPR. Professional medical assistance shall be obtained at the earliest possible opportunity. The nearest hospital and clinic to HPS is shown on a map that is part of every SHSP. A general map to the nearest clinic and hospital is attached to this plan (Figure 12-1).

### 12.5.2 Minor Injury

- Contact a supervisor or "buddy."
- Have qualified first aid personnel treat injury.
- Record injury and include name of injured person, nature of injury, and treatment given.

### 12.5.3 Medical Emergency

In the event of a medical emergency when actual or suspected serious injury occurs, the following procedures shall be implemented:

- Survey scene and evaluate whether the area is safe for entry.
- Remove the exposed or injured person(s) from immediate danger.
- Render first aid if necessary. Decontaminate affected personnel after critical first aid is given.
- Obtain paramedic services or ambulance transport to local hospital. This procedure shall be followed even if there is no visible injury.
- Call 911 from phones on HPS. Calling 911 from cell phones will notify California Highway Patrol who will notify county Emergency Medical Service.
- Identify location by number of nearest building, request medical assistance, and provide name and telephone number.

- Request assistance from emergency medical service and/or additional assistance.
- Other personnel in the work area shall be evacuated to a safe distance until the Site Superintendent determines that it is safe for work to resume. If there is any doubt regarding the condition of the area, work shall not commence until all hazard control issues are resolved.
- Notify ROICC of incident and fill out accident reporting forms and associated documents.

### 12.5.4 Fatal Injury

If a fatal injury occurs, the following additional steps will be followed:

- Notify the Site Superintendent immediately.
- Notify PESM who will initiate contact with Cal-OSHA and other appropriate agencies.
- Notify ROICC.
- All work activities on the project must be stopped on the project for 24 hours.
- Assist Cal-OSHA as directed.

## 12.6 DECONTAMINATION DURING MEDICAL EMERGENCIES

Any personnel requiring emergency medical attention shall be evacuated immediately from exclusion and contamination reduction zones. Personnel shall not enter the area to attempt a rescue if their own lives would be threatened. The decision whether or not to decontaminate a victim prior to evacuation is based on the type and severity of the illness or injury and the nature of the contaminant.

For some emergency victims, immediate decontamination may be an essential part of life saving first aid. For others, decontamination may aggravate the injury or delay life saving treatment. If decontamination does not interfere with essential treatment, it should be performed.

If decontamination can be performed:

- Wash external clothing and cut it away.
- Wrap victim in clean blanket or towel if necessary.

If decontamination cannot be performed:

- Wrap the victim in blankets or plastic to reduce contamination of other personnel.
- Alert emergency and off-site medical personnel to potential contamination; instruct them about specific decontamination procedures.
- Send along site personnel familiar with the incident.

## 12.7 EMERGENCY SITE EVACUATION PROCEDURES

In the event of an emergency situation such as fire or explosion, the SHSS or a supervisor will activate an air horn for approximately 15 seconds indicating the initiation of evacuation procedures. All personnel in both the restricted and non-restricted areas will evacuate and assemble near the support zone or other safe area as identified by the SHSS. Prior to start of work at any project site the SHSS will identify and mark the location of an evacuation assembly area for that project site. The location should be upwind of the site as determined by the wind direction. For efficient and safe site evacuation and assessment of the emergency situation, the Site Superintendent or SHSS will have authority to initiate proper action if outside services are required. Under no circumstances will incoming personnel or visitors be allowed to proceed into the area once the emergency signal has been given. The SHSS must ensure that access for emergency equipment is provided and that all equipment that may cause combustion has been shut down once the alarm has been sounded. As soon as possible, and while the safety of all personnel is confirmed, emergency agency notification will commence. The SHSS will brief site personnel each day as to the location of the evacuation assembly area. After assembly at the local site assembly point, depending on the nature of the emergency workers may be instructed to re-assemble at the office trailers of TtFW located on Nimitz Avenue.

Prior to the start at each project worksite, the SHSS will establish safe egress routes from the site to the evacuation assembly area. The SHSS will prepare a drawing or map that diagrams these safe egress routes. The SHSS will use this same map to diagram egress from the evacuation assembly area to the facility gate to be used as an exit. From this point, the map showing the route to the nearest clinic and the nearest hospital will be used if medical services are required.

## 12.8 FIRE PREVENTION AND PROTECTION

Fire prevention and protection measures require pre-planning. At least one 20-pound dry chemical ABC fire extinguisher will be located at each project site. A mounted fire extinguisher is required in every vehicle including heavy equipment. Extinguishers mounted on heavy equipment will be a minimum 5-pound ABC dry chemical fire extinguisher. Fire extinguishers inside the cab of pickup trucks will be 2 ½ -pound dry chemical ABC. Fire extinguishers in the cabs of all vehicles must be mounted or secured. Employees will follow safe work practices to include proper storage of flammable and combustible liquids. Smoking is permitted only in those areas designated specifically by the PjM, Site Superintendent or SHSS. Personnel will follow hot work procedures to ensure that work is performed in a safe environment. In the event of a fire or explosion, summon the Fire Department immediately, take a head count, and implement evacuation procedures.

## 12.9 SPILL CONTROL AND RESPONSE

All spills, leaks, and fires involving oil or hazardous substances at HPS must be reported to the to the RPM and the PESM. The person reporting the leak or spill is required to provide the following information:

- His/her name
- Location of spill and facility number, if known
- Number of injured personnel and nature of injuries, if known
- Substance spilled
- Amount spilled (estimate)
- Extent of spill
- Rate that substance is currently being released (estimate)
- Time spill occurred (estimate)
- Any other pertinent information

The RPM in coordination with the PjM will manage notifications to regulatory agencies. In addition, all spills will be reported to the TtFW Environmental Compliance Manager or the PESM. Project personnel will not report spills directly to any agency unless specifically requested by the RPM or Contracting Officer.

A minor spill would involve no immediate threat to human health or the environment, minimal property damage, and does not exceed the reportable quantity (RQ) for that material. In the event of a minor spill, the appropriate response action is for the responsible person to notify the RPM and the PjM and supply the responders with as much information as possible. In the case of a spill of contaminated or hazardous materials, the following procedures shall be followed:

- Notify the Site Superintendent
- Identify protective clothing or equipment required to respond
- Contain the spill
- Neutralize and/or solidify any product
- Transfer material into 55-gallon drums
- Document incident

### 12.9.1 Release Prevention and Minimization Measures

In addition to training, the following procedures will be implemented to prevent and minimize releases of hazardous materials:

- Do not conduct hazardous materials operation when the weather could cause significant risk to surrounding area if a spill should occur.
- Transfer all materials in or over a bermed or "protected" area. A protected area is one that is covered with an impermeable material, such as polyethylene.
- Dike temporary storage tanks containing hazardous wastes or potentially hazardous wastes to contain potential releases.
- Maintain a supply of basic spill response materials and protective equipment on site to include:
  - Absorbent sheets, pillows, booms or absorbent material
  - Open top 55-gallon drums or other containers with lids
  - Booms, shovels, and other tools, such as squeegees

## 12.10 SIGNIFICANT VAPOR RELEASE

Any project activity which releases significant amounts of vapor must be reported immediately, as described in the spill release procedure. Every attempt to mitigate the release must be taken if it can be safely performed. For example, during excavations vapor releases may be controlled by simply replacing cover on the excavation. Downwind evacuation procedures may be required. These will be initiated through coordination with HPS emergency coordinators.

## 12.11 EARTHQUAKE RESPONSE

If an earthquake should occur during the course of site activities, take the following steps:

- Stop working. Remain calm and do not panic.
- Do not use or do anything that might be a source of ignition (smoking, cutting, or welding).
- Avoid power lines, power poles, and windows.
- If in a vehicle, stay in the vehicle until the earthquake is over.
- If in a building, take cover under a heavy piece of furniture or leave the building if possible. Buildings at HPS have not been maintained and many of them are subject to collapse in an earthquake.

After the earthquake is over:

- Prepare for aftershocks. Stay out of severely damaged buildings.
- Meet for a head count at a location designated by the Site Superintendent.
- Check for injuries. Do not move seriously injured personnel, unless remaining where they are would create danger of further injury.

- Check vehicles, equipment, and buildings for any obvious damage. Do not enter any buildings until their structural integrity has been evaluated.
- Check utility lines for damage. Switch off power, water and gas until a utility official has inspected the buildings and operational area and determined it is safe.
- If driving, watch carefully for hazards created by the earthquake (undermined roads, weak bridges, or overpasses, fallen power lines or poles, and so forth).

## 12.12 EMERGENCY EQUIPMENT

The following emergency equipment will be brought onto the site or will be stationed near each work area:

- Fire extinguisher, minimum one 20-pound dry chemical ABC type in the CRC at the edge of exclusion zone.
- Industrial first aid kit, in the CRC, at the edge of the support zone.
- Portable eye wash, capable of supplying 15 minutes of water and protected from direct sunlight in the support area, at the edge of the support zone.
- Air horn at the support area, at the edge of the support zone.
- Spill control material consisting of absorbent pillows or absorbent material and shovels, plastic sheeting, and 55-gallon drum(s) in the support zone by the CRC entrance.

The following equipment will be available at the support trailer for use in an emergency situation:

- Industrial first aid kit
- Blanket

Each SHSP may specify additional emergency equipment consistent with the hazards associated with the CTO. For example, some projects may require that SCBAs be available for work on projects where exposure to contaminants may require their use.

## 12.13 EMERGENCY INFORMATION POSTINGS

Emergency contact names and phone numbers will be posted at every project site (Table 12-1). A map showing egress routes, evacuation assembly areas, and the route to the clinic and the hospital will also be posted. At some remote locations, posting may not be practical. In this case, the contact names, phone numbers and maps will be placed on the dashboard of every vehicle. These postings and maps are prepared for each SHSP.

# 13.0 TRAINING

In accordance with TtFW corporate policy and pursuant to 29 CFR, Part 1910.120 (8 CCR, Section 5192), hazardous waste site workers shall, at the time of job assignment, have received a minimum of 40 hours of initial health and safety training for HAZWOPER, unless excepted by the above reference. At a minimum, the training shall have consisted of instruction in the topics outlined in the above reference. Personnel who have not met the requirements for initial training shall not be allowed to work in any site activities that may expose them to chemical or physical hazards.

An employee's prior experience and/or training for equivalency may be considered to meet the training described above. The PESM will make the determination if previous experience and/or training meet the initial training requirements.

In addition to the required initial training, each employee shall have received 3 days of directly supervised on-the-job training at a hazardous waste site. This training shall have addressed the duties the employees are expected to perform and be properly documented. The TtFW Site Superintendent has the responsibility for ensuring that personnel assigned to field sites comply with these requirements. The Site Superintendent will provide the DON Contracting Officer or designee with written certification of completion of the required training and maintain copies of required training records at the work site.

## 13.1 MANAGER/SUPERVISOR TRAINING

In accordance with 29 CFR, Part 1910.120 (8 CCR, Section 5192), on-site managers and supervisors directly responsible for, or who supervise employees engaged in hazardous waste operations, shall receive training as required above and at least 8 additional hours of specialized training on managing such operations by the time of job assignment.

## 13.2 ANNUAL 8-HOUR REFRESHER TRAINING

Annual 8-hour refresher training will be required of all hazardous waste site field personnel to maintain their qualifications for fieldwork. The following topics will be reviewed: toxicology, respiratory protection—including air purifying devices and SCBA—medical surveillance, decontamination procedures, and personal protective clothing. In addition, topics deemed necessary by the SHSS or PESM may be added to the above list.

## 13.3 SITE-SPECIFIC TRAINING

Prior to commencement of field activities, the SHSS will provide site-specific training to all personnel assigned to the site; this training will specifically address the activities, procedures, monitoring, and equipment for the site operations. Training will include site and facility layout, hazards, and emergency services at the site, hazard communication, and will highlight all provisions contained within the SHSP. This training will also allow field workers to clarify anything they do not understand and to reinforce their responsibilities regarding safety and health for their particular activity. Additional training, if required for completion of field tasks during the site work, will be identified and provided for personnel as the work progresses.

## 13.4 RADIATION WORKER TRAINING AND RADIATION AWARENESS TRAINING

Workers that perform radiation-related work under a Nuclear Regulatory Commission license may be required to have specific training as required under that license. This training is specified in the license. The SHSS will review training records to ensure that all workers required to have this training have documentation in their training records.

All workers at HPS will receive, at a minimum, radiation awareness training. This training will address the hazards associated with radiation, the types of radioactivity expected to be encountered, protective measures, and what should be done if they encounter suspicious objects or known radioactive materials. This training will be documented in each employee's training record.

## 13.5 ASBESTOS AND LEAD AWARENESS TRAINING

HPS has many buildings and areas that have asbestos-containing materials and at a minimum lead-based paint. All workers at HPS must receive asbestos awareness training and lead awareness training prior to performing any work activity at HPS. The training course is a course that has been prepared by TtFW on each subject. The course is usually presented by the SHSS. Documentation of this training must be in each employee's training record.

## 13.6 ON-SITE SAFETY BRIEFINGS

Project personnel and visitors will be given daily on-site health and safety briefings by the SHSS, or designee, to assist site personnel in safely conducting their work activities. This training will be conducted prior to the start of new work activities using AHAs. The briefings will include information on new operations to be conducted, changes in work practices, or changes in the site's environmental conditions. The briefings will also provide a forum to facilitate conformance with safety requirements, and identify performance deficiencies related to safety during daily activities or as a result of safety inspections.

## 13.7 FIRST AID AND CPR

The SHSS will identify those individuals requiring first aid and CPR training. At a minimum, the SHSS will have received first aid and CPR training. At least two persons trained and current in certification of first and aid and CPR will be present at every worksite. The training will be consistent with the requirements of the American Red Cross Association.

# 14.0 LOGS, REPORTS, AND RECORDKEEPING

The following is a summary of required health and safety logs, reports, and recordkeeping for this contract.

## 14.1 SITE HEALTH AND SAFETY PLAN CHANGE APPROVAL FORM

A Site Health and Safety Plan Change Approval Form is to be completed for all changes to the SHSP. This form requires the signatures of the PjM or Site Superintendent, the SHSS, and the PESM. Upon request, the PESM sends a copy of this form to the DON CIH within 5 workdays for review. Substantial changes to the SHSP may require a Field Change Request (FCR) according to the QC Plan in order to initiate a significant change to the SHSP. PESM approval of each FCR is required. Copies of the FCR affecting the SHSP are also sent to the DON CIH.

## 14.2 MEDICAL AND TRAINING RECORDS

Full medical and training records are normally kept by the employer. Proof of the most recent training and medical qualification must be provided to the SHSS by the employee. The SHSS will keep a file containing appropriate training and medical qualifications for site workers. Medical records will be maintained in accordance with 29 CFR, Part 1910.20 (8 CCR, Section 3204). The examining physician retains custody of the complete medical record. Employee records have only the physician statement of medical qualification for duty and the employee's fitness to wear a respirator.

## 14.3 ON-SITE LOG

A log of personnel (including job title, level of protection, and work location) will be kept on site each day by the SHSS or designee. Originals will be kept in the project file.

## 14.4 EXPOSURE RECORDS

Any personal monitoring results, laboratory reports, calculations, and air sampling data sheets are part of an employee exposure record. These records will be kept in accordance with 29 CFR, Part 1910.20 (8 CCR, Section 3204). For TtFW employees, the originals will be sent to the records coordinator. For subcontractor employees, the originals will be sent to the subcontractor employer and a copy kept in the project file.

## 14.5 ACCIDENT/INCIDENT REPORTS

A TtFW accident/incident report must be completed following any event involving emergency first aid, lost time, or property damage. The originals will be sent to the TtFW records coordinator for maintenance and distribution by TtFW. Copies will be distributed to the PESM,

Site Superintendent, subcontractor employees, if appropriate, and the DON Contracting Officer. A copy of the completed forms will be kept in the project file.

## 14.6 OSHA FORM 300

An OSHA Form 300 (Log of Occupational Injuries and Illnesses) will be kept at the project site. All recordable injuries or illnesses will be recorded on this form. At the end of the project, the original will be sent to the TtFW records coordinator for maintenance. Subcontractor employers must also meet the requirements of maintaining an OSHA Form 300. The TtFW accident/incident report meets the requirements of the OSHA Form 301 (Supplemental Record) and must be maintained with the OSHA Form 300 for all recordable injuries or illnesses.

## 14.7 HEALTH AND SAFETY FIELD LOGBOOKS

The SHSS will complete and maintain the daily logbook at the site. Logbooks will be used to document important events as they occur. Some general procedures will pertain to the use of all logbooks. The following information will be recorded on each page of all logbooks:

- Initials of persons making entry
- Date
- Time of each entry (military time)
- Location

The logbook will be signed at the end of each day or work shift. All entries will be made in black ink. No pages will be removed from the logbook and each page will be numbered. Any corrections will be made with a single line through the entry, and initialed.

The logbook will be used to record daily site conditions and activities within the exclusion zones. The logbook will contain the following items:

- Names and job titles of all personnel in the work group
- Level of protection
- Health and safety monitoring equipment used
- Weather conditions
- Work/rest schedule (if appropriate)
- A description of the activities as they are occurring
- Any pertinent health and safety observations
- Sample number (if appropriate)

Copies of the logbooks will be submitted to the Site Superintendent as necessary. The original logbooks will become part of the exposure records file and will be maintained by the TtFW records coordinator.

## 14.8 MATERIAL SAFETY DATA SHEETS

MSDSs will be obtained and kept on file at the project site for each hazardous chemical brought to, used, or stored at the site. An MSDS for each contaminant will also be maintained. The MSDS will be kept on file by the SHSS at the project site.

## 14.9 CLOSEOUT SAFETY REPORT

A final closeout safety report will be provided to the PESM summarizing the safety performance achieved during the site work. Specific elements of the report will include the following:

- A description of significant events, exposures, accidents, illnesses, and actions taken to prevent their occurrence.
- A summary of monitoring results including air, noise, radiation, and heat stress samples.
- A description of any state or federal inspections involving the health and safety of site workers.

## 14.10 REQUIRED POSTINGS

- Department of Labor
    1. Minimum Wage
    2. Polygraph Protection Act
    3. Equal Employment Opportunity
    4. Job Safety and Health
    5. Family Leave
- Cal-OSHA
    1. Safety and Health Protection on the Job
    2. Discrimination in Employment
    3. California Workers Compensation (Sign begins: " If a work injury occurs...")
    4. Emergency Phone Numbers
    5. Notice of Unemployment and Disability Insurance
    6. Access to Medical and Exposure Records
    7. Hearing Protection Standard

8. For sites where radioactive materials are used or stored (Ni-63 in electron capture detectors, density meters such as Troxler):
    1) Standard for Protection Against Radiation
    2) Notice: Current Copy of Radiation Control Regulations and Radiation Control Officer
9. California Law also requires a posting of what day is payday and a multipage document regarding minimum wage.
10. Operating Rules for Forklifts if forklifts are used on project
11. California's Accident and Injury Illness Prevention Program: a management policy on Health and Safety

- Contract Requirements
    1. Posting of HOTLINE POSTER
    2. Drug Policy Poster
    3. Posting of Prevailing Wages
- Company (TtFW) Required Postings
    1. Policy on Sexual Harassment
    2. Policy on Equal Employment Opportunity
    3. Accident/Injury Reporting
    4. Environmental Safety and Quality Poster (ISO 14001)
    5. Recycling and use Double Sides Posters
    6. TtFW ZIP Poster
    7. TtFW Work Rules

# 15.0 FIELD PERSONNEL REVIEW

All personnel are required to be trained in this Base-Wide Plan and each SHSP. Upon completion of this training and review, all project personnel will acknowledge this training by signing a review form acknowledging training in this Base-Wide Plan. A separate form will be used to acknowledge training in each SHSP.

# 16.0 REFERENCES


American Conference of Governmental Industrial Hygienists (ACGIH). Most current publication. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices.

American Iron and Steel Institute. 1993. *Wire Rope Users Manual.*

Department of the Navy (DON)/Marine Corps. 2000. Navy/Marine Corps Installation Restoration Manual. August.

Tetra Tech FW, Inc. (TtFW) Corporate Health and Safety Program Manual (most recent).

TtFW Project Rules Handbook, Volumes I and II (most recent).

U.S. Army Corps of Engineers. 1996. U.S. Army Corps of Engineers Safety and Health Requirements Manual, EM 385-1-1, 3 September.

U.S. Department of Health and Human Services. 1985. Occupational Safety and Health Guidance for Hazardous Waste Site Activities.


***Note***:

Where no date is given in the references above, it is assumed that the reference used will be the most recent publication. Specific references unique to a project will either be listed as an attachment to the SHSP or they will be incorporated as a separate section to the SHSP. For example, a specific procedure for personal air sampling may be included as a reference within the SHSP.

# FIGURES

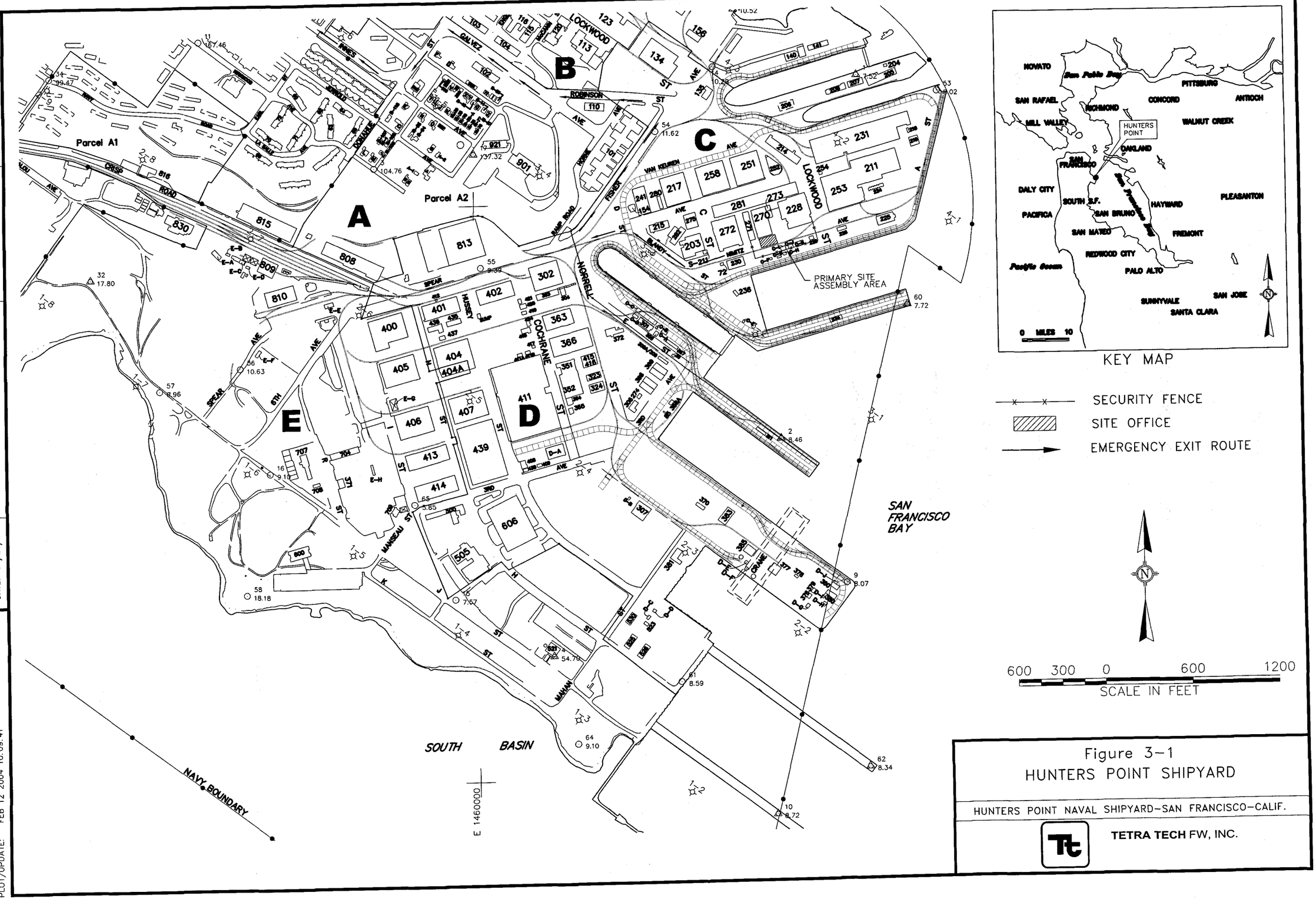


Figure 3-1
HUNTERS POINT SHIPYARD

HUNTERS POINT NAVAL SHIPYARD-SAN FRANCISCO-CALIF.

TETRA TECH FW, INC.

| | | | |
|---|---|---|---|
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## LEGEND

- TTFWI SITE OFFICES
- CONCENTRA MEDICAL CENTER OCCUPATIONAL HEALTH CLINIC
- SAN FRANCISCO GENERAL HOSPITAL
- ROUTE TO CLINIC
- ROUTE TO HOSPITAL

Concentra Medical Center ..... (415) 648-9501
Occupational Health Clinic
728 20th Street
San Francisco, CA 94107

Hours of Operation: 7:30 A.M. - 5:00 P.M. (Mon. – Fri)

From the TTFW offices at HPS, use Nimitz to go towards the main gate. (The Innes Avenue gate is the only open gate to HPS). Once on Innes, continue northwest on Innes, bear right on to Hunters Point Boulevard. Continue on Hunters Point Boulevard which becomes Evans. Continue on Evans and turn right at 3rd Street. Continue on 3rd Street past Cesar Chavez until 20th Street. Tun left, clinics are on right.

San Francisco General Hospital ..... (415) 206-8000
1001 Potrero Avenue
San Francisco, CA 94110

From the TTFW offices at HPS, use Nimitz to go towards the main gate. (The Innes Avenue gate is the only open gate to HPS). Once on Innes, continue northwest on Innes, bear right on to Hunters Point Boulevard. Continue on Hunters Point Boulevard which becomes Evans. Continue on Evans and turn right at 3rd Street. Continue to Cesar Chavez. Turn left onto Cesar Chavez. Continue west on under the 280 Freeway and continue to under the 101 Freeway, turn right on Potrero. Continue on Potrero, hospital will be on the right on 23rd Street.

N

NOT TO SCALE

Figure 12–1
**ROUTE TO CLINIC AND HOSPITAL**

HUNTERS POINT SHIPYARD, SAN FRANCISCO

TETRA TECH FW, INC.

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# TABLES

# TABLE 12-1

## EMERGENCY INFORMATION

**REPORT ALL FIRES, SERIOUS INJURY, OR UNCONTROLLED SPILLS IMMEDIATELY: 911**

| | | | |
|---|---|---|---|
| **Clinic:** | Concentra Medical Center (415) 648-9501<br>Occupational Health Clinic<br>728 20th Street<br>San Francisco, CA 94107<br><br>Hours of Operation: 7:30 a.m. - 5:00 p.m. (Monday – Friday)<br><br>From the TtFW offices at HPS, use Nimitz to go toward the main gate. (The Innes Avenue gate is the only open gate to HPS.) Once on Innes, continue northwest on Innes, bear right on to Hunters Point Boulevard. Continue on Hunters Point Boulevard, which becomes Evans. Continue on Evans and turn right at 3rd Street. Continue on 3rd Street, past Cesar Chavez until 20th Street. Turn left, clinic is on the right. | | |
| **Hospital:** | San Francisco General Hospital (415) 206-8000<br>1001 Potrero Avenue<br>San Francisco, CA 94110<br><br>From the TtFW offices at HPS, use Nimitz to go toward the main gate. (The Innes Avenue gate is the only open gate to HPS.) Once on Innes, continue northwest on Innes, bear right on to Hunters Point Boulevard. Continue on Hunters Point Boulevard, which becomes Evans. Continue on Evans and turn right at 3rd Street. Continue to Cesar Chavez. Turn left onto Cesar Chavez. Continue west on under the 280 Freeway and continue to under the 101 Freeway, turn right on Potrero. Continue on Potrero. Hospital will be on the right on 23rd Street. | | |
| **Fire/Police/EMS:** | **911**<br>There is a federal fire department and Department of Defense Police on HPS, but they should be contacted through the 911 number.<br><br>***911 calls from a cell phone do not go directly to HPS emergency services, but through the California State Highway Patrol.*** | | |
| **TtFW Contacts:** | Project Manager<br>Glenn Starr<br>(619) 471-3517<br>cell: (619) 602-6483 | Project PESM (CIH)<br>Roger Margotto<br>(619) 471-3503<br>pager: (714) 810-3742 | Project SHSS<br>Richard Quinn, CSP<br>(415) 671 –1990<br>cell: (650) 450-1969 |
| **RPM:** | Jose Payne (619) 532-0952 | | |
| **ROICC:** | Peter Strohanoff<br>Project Engineer<br>(510) 749-5941 | Andy Uehisa<br>Construction Management Technician<br>(510) 749-5946 | |

# TABLE 12-1

## EMERGENCY INFORMATION

| | |
|---|---|
| **CSO:** | Michael Mentink (415) 743-4729 (415) 559-9851 (cell)<br>Environmental Compliance Manager |
| **Poison Control Center:** | California Poison Control System, Central Office<br>Emergency Phone: (800) 876-4766 [All of CA] |
| **CHEMTREC:** | (800) 424-9300 |
| **National Response Center:** | (800) 424-8802 |
| **RCRA Hotline:** | (800) 424-9346 |

***Notes:***

| | | | |
|---|---|---|---|
| CHEMTREC | Chemical Transportation Emergency Center | PESM | Project Environmental and Safety Manager |
| CIH | Certified Industrial Hygienist | RCRA | Resource Conservation and Recovery Act |
| CSO | Caretaker Site Office | ROICC | Resident Officer in Charge of Construction |
| CSP | Certified Safety Professional | RPM | Remedial Project Manager |
| EMS | Emergency Medical Services | SHSS | Site Health and Safety Specialist |
| HPS | Hunters Point Shipyard | TtFW | Tetra Tech FW, Inc. |

# ATTACHMENT 1

# MATERIAL SAFETY DATA SHEETS

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



## Section 1. Material Identification



**Antimony Trioxide ($Sb_2O_3$) Description:** Derived by heating antimony ore and recondensing the fumes, adding ammonium hydroxide to antimony chloride, or direct extraction from low-grade ores. Used in fire retarding of textiles, paper, and plastics (chiefly PVC); paint pigments; high stability specialty lubricants; phosphors; as a ceramic opacifier; catalyst; mordant; glass decolorizer; and chemical intermediate.
**Other Designations:** CAS No. 1309-64-4, antimonious oxide, antimony peroxide, antimony sesquioxide, antimony white, Antox, C.I. Pigment White II, Dechlorane-A-O, diantimony trioxide, Exitelite, flowers of antimony, Senarmontite, Valentinite, White Star.
**Manufacturer:** Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

**Cautions:** Antimony trioxide is an eye, skin, and mucous membrane irritant and is considered a suspected human carcinogen. The powder form will ignite and burn in air when heated.

*powder*

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

Genium

*cubes*

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

* Chronic effects

PPE†
† Sec. 8

## Section 2. Ingredients and Occupational Exposure Limits

Antimony trioxide, < 100%. Impurities include arsenic.

**1992 OSHA PEL**
Transitional & Final Rule Limits
8-hr TWA: 0.5 mg/m$^3$ (as Sb)

**1990 IDLH Level**
80 mg/m$^3$ (as Sb)

**1992 NIOSH REL**
TWA: 0.5 mg/m$^3$ (as Sb)

**1993-94 ACGIH TLV**
TWA: 0.5 mg/m$^3$ (handling and use, as Sb)

**1991 DFG (Germany) MAK**
TWA: 0.5 mg/m$^3$ (as Sb)
Category III: Substances with systemic effects
Onset of effects; > 2 hr
Half life: > shift length (strongly cumulative)
Peak Exposure limit: 5 mg/m$^3$, 30 min. average value, 1/shift

**1992 Toxicity Data***
Rat, inhalation, $TC_{Lo}$: 4200 µg/m$^3$ given intermittently for 52 weeks caused liver and lung tumors.
Rat, oral, $LD_{50}$: > 20 g/kg
Rat, inhalation, $TC_{Lo}$: 270 µg/m$^3$ from 1 to 21 days of pregnancy caused post-implantation mortality or fetal death.

* See NIOSH, *RTECS* (CC5650000), for additional mutation, reproductive, tumorigenic, and toxicity data.

## Section 3. Physical Data

**Boiling Point:** 843.3 °F (1550 °C), *sublimes**
**Melting Point:** 346.1 °F (655 °C)
**Vapor Pressure:** 1 mm Hg at 574 °F (1065.2 °C)
**pH:** Amphoteric (can react as an acid or a base)
**Molecular Weight:** 291.5

**Density:** 5.2
**Water Solubility:** Insoluble; 0.000029 mole/1000 g water at 77 °F (25 °C).
**Other Solubilities:** Soluble in sulfuric, hydrochloric, and nitric acids; potassium hydroxide; warm tartaric acid; bitartrates; alkali hydroxides and sulfides.

**Appearance and Odor:** White, odorless, crystalline powder or cubes.
* Sublimes in high vacuum at 752 °F (400 °C)

## Section 4. Fire and Explosion Data

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

**Extinguishing Media:** The powder ignites and burns when heated; the cubes don't. Use dry chemical, carbon dioxide, water, or regular foam.
**Unusual Fire or Explosion Hazards:** The more finely divided the powder, the more readily it burns.
**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:** Antimony trioxide is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
**Chemical Incompatibilities:** Include chlorinated rubber (at 420.8 °F/216 °C), bromine trifluoride, acids, oxidizers, and halogenated agents.
**Conditions to Avoid:** Excessive dust generation, exposure to heat or ignition sources, and contact with incompatibles.
**Hazardous Products of Decomposition:** Thermal oxidative decomposition of antimony trioxide can produce toxic antimony fumes.

## Section 6. Health Hazard Data

**Carcinogenicity:** The ACGIH, TLV-A2 (suspected human carcinogen for $Sb_2O_3$ *production*)[183] and DFG, MAK-A2 (unmistakably carcinogenic animals only, $Sb_2O_3$ *handling and use*),[183] list antimony trioxide as a carcinogen.
**Summary of Risks:** Antimony trioxide is irritating to the eyes, skin, and respiratory tract. Chronic exposure appears to be more of a threat than acute exposure and is evident by heart disease, "antimony measles", and possible carcinogenicity. Liver and kidney damage is seen in animals but it is not clear if the same damage could occur in humans. Due to its insolubility in water, antimony trioxide is less toxic than soluble antimony salts. In addition, it is three times less toxic than the metal.
**Medical Conditions Aggravated by Long-Term Exposure:** Skin, heart, and lung disorders.
**Target Organs:** Eyes, skin, and the respiratory and cardiovascular systems.
**Primary Entry Routes:** Inhalation, skin and eye contact, ingestion.

*Continue on next page*

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## Section 6. Health Hazard Data, *continued*

**Acute Effects:** Inhalation can cause sore throat, headache, chest pain, shortness of breath, metallic taste, nausea and vomiting, diarrhea, and weight loss. Skin contact is irritating. Eye contact is irritating and can cause conjunctivitis. Ingestion causes irritation of the gastrointestinal tract, vomiting, bloody stools, slow pulse and low blood pressure, shallow breathing, and possibly, coma and convulsions resulting in death.
**Chronic Effects:** Chronic inhalation can cause inflammation of the respiratory tract resembling simple pneumoconiosis and is shown by radiographic lung changes (studied individuals were exposed up to 10 X the TLV). Lung cancer is possible based on an English epidemiologic study but at present, $Sb_2O_3$ only has status as a suspected carcinogen. There is also evidence of chronic heart disease due to effects on the heart muscle. Repeated or prolonged skin contact may cause "antimony measles ", consisting of itchy papules and pustules around the sweat and fat glands. This is particularly seen in moist areas (elbows, underarms, groin area, etc.). The condition appears to be more prevalent when temperatures are high.
**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 to remove any loose material, then wash with soap and water. For reddened or blistered skin, consult a physician.
**Inhalation:** Remove exposed person to fresh air and support breathing as needed.
**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.
**After first aid, get appropriate in-plant, paramedic, or community medical support.**
**Note to Physicians:** Support respiratory and cardiovascular function. A urine test can be used to confirm exposure-1 mg/L is indicative of potentially harmful exposure. Chelators such as BAL and unithiol have been used in some countries.

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against inhalation and skin/eye contact. Avoid dust generation; do not sweep. Carefully scoop spills into suitable containers for disposal. Damp mop any residue. Vacuuming (with an appropriate filter) may also be used. Prevent entry into sewers, drains, and waterways. Follow applicable OSHA regulations (29 CFR 1910.120).
**Environmental Transport:** Antimony trioxide is not expected to volatilize from water because of its low vapor pressure.
**Ecotoxicity Values:** *Lepomis macrochirus* (bluegill sunfish), $LD_{50}$ = > 530 mg/L/96 hr; *Pimephales promelas* (fathead minnow), $LD_{50}$ = > 833 mg/L/96 hr.
**Disposal:** Consider returning large amounts to a smelter for reprocessing. 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): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311 (b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
**OSHA Designations**
Listed (as Sb) 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. Consider the NIOSH respirator recommendations for antimony dust because there are no specific recommendations for antimony trioxide. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Butyl rubber and polycarbonate are suitable materials. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove $Sb_2O_3$ from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using $Sb_2O_3$, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9. Special Precautions and Comments

**Storage/Handling Requirements:** Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from incompatibles.
**Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level.
**Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on the skin, lungs, and heart.

**Transportation Data (49 CFR 172.101)**

**DOT Shipping Name:** Antimony compounds, inorganic, solid, n.o.s.
**DOT Hazard Class:** 6.1
**ID No.:** UN1549
**DOT Packing Group:** III
**DOT 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:** —

***MSDS Collection* References:** 1, 26, 73, 101, 103, 124, 126, 127, 132, 133, 136, 139, 159, 167, 168, 176, 183, 186
**Prepared by:** M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** T Thoburn, MPH, MD

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## Section 1. Material Identification

**Arsenic Description:** Obtained from flue dust of copper and lead smelters as white arsenic (arsenic trioxide). Reduction with charcoal and sublimation in an $N_2$ current yields pure arsenic. Metallic arsenic is used for hardening copper, lead, and alloys; as a doping agent in germanium and silicon solid-state products, special solders, and medicine; and to make gallium arsenide for dipoles and other electronic devices. Arsenic compounds are used in manufacturing certain types of glass; in textile printing, tanning, taxidermy, pharmaceuticals, insecticides and fungicides, pigment production, and antifouling paints; and to control sludge formation in lubricating oils. Arsenic trioxide is the source for 97% of all arsenic products.
**Other Designations:** CAS No. 7440-38-2; arsen; arsenic black; As; gray arsenic; metallic arsenic.
**Manufacturer:** Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

| | |
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| S | 2 |
| K | 0 |

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## Section 2. Ingredients and Occupational Exposure Limits

Arsenic and soluble compounds, as As

**OSHA PEL**
8-hr TWA: 0.5 mg/m³,* 0.01 mg/m³†

**ACGIH TLV, 1989-90**
TLV-TWA: 0.2 mg/m³

**NIOSH REL, 1987**
Ceiling: 0.002 mg/m³

**Toxicity Data‡**
Man, oral, $TD_{Lo}$: 76 mg/kg administered intermittently over a 12-year period affects the liver (tumors) and blood (hemorrhage)
Man, oral: 7857 mg/kg administered over 55 years produces gastrointestinal (in the structure or function of the esophagus), blood (hemorrhage), and skin and appendage (dermatitis) changes
Rat, oral, $TC_{Lo}$: 605 µg/kg administered to a 35-week pregnant rat affects fertility (pre- and post-implantation mortality)

* Organic compounds.
† Inorganic compounds.
‡ See NIOSH, *RTECS* (CG0525000), for additional mutative, reproductive, tumorigenic, and toxicity data.

## Section 3. Physical Data*

**Boiling Point:** sublimes at 1134 °F/612 °C
**Melting Point:** 1497 °F/814 °C
**Vapor Pressure:** 1 mm at 702 °F/372 °C (sublimes)
**Atomic Weight:** 74.92
**Density:** 5.724 at 57 °F/14 °C
**Water Solubility:** Insoluble†

**Appearance and Odor:** A brittle, crystalline, silvery to black metalloid. Odorless.

* This data pertains to arsenic only.
† Arsenic is soluble in nitric acid ($HNO_3$).

## Section 4. Fire and Explosion Data

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

**Extinguishing Media:** Use dry chemical, $CO_2$, water spray, or foam to fight fires.
**Unusual Fire or Explosion Hazards:** Flammable and slightly explosive in the form of dust when exposed to heat or flame.
**Special Fire-fighting Procedures:** Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

## Section 5. Reactivity Data

**Stability/Polymerization:** Arsenic is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
**Chemical Incompatibilities:** Arsenic can react vigorously on contact with powerful oxidizers such as bromates, peroxides, chlorates, iodates, lithium, silver nitrate, potassium nitrate, potassium permanganate, and chromium (VI) oxide. This material is also incompatible with halogens, bromine azide, palladium, dirubidium acetylide, zinc, and platinum.
**Hazardous Products of Decomposition:** Thermal oxidative decomposition of arsenic and its compounds produces irritating or poisonous gases.

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## Section 6. Health Hazard Data

**Carcinogenicity:** The IARC, NTP, and OSHA list arsenic as a human carcinogen (Group 1). This evaluation applies to arsenic and arsenic compounds as a whole, and not necessarily to all individual chemicals within the group. Studies report that both the trivalent and pentavalent compounds are strongly implicated as causes of skin, lung, and lymphatic cancers. Experimental studies have shown that arsenic has tumorigenic and teratogenic effects in laboratory animals.
**Summary of Risks:** Arsenic compounds are irritants of the skin, mucous membranes, and eyes. The moist mucous membranes are most sensi[illegible] to irritation. Prolonged contact results in local hyperemia (blood congestion) and later vesicular or pustular eruption. Epidermal carcinoma is a [illegible] reported risk of exposure. Peripheral neuropathy (degenerative state of the nervous system) is common after acute or chronic arsenic poisoning. Symptoms include decreased sensation to touch, pinprick, and temperature; loss of vibration sense; and profound muscle weakness and wasting. Other complications of acute and chronic arsenic poisoning are encephalopathy (alterations of brain structure) and toxic delirium.
**Medical Conditions Aggravated by Long-Term Exposure:** Damage to the liver, nervous, and hematopoietic (responsible for the formation of blood or blood cells in the body) system may be permanent. Pulmonary and lymphatic cancer may also occur.
**Target Organs:** Liver, kidneys, skin, lungs, lymphatic system.
**Primary Entry Routes:** Inhalation, ingestion of dust and fumes, via skin absorption.
**Acute Effects:** Acute industrial intoxication is more likely to arise from inhalation of arsine. However, with corrosive arsenical vapors, conjunctivitis, eyelid edema, and even corneal erosion may result. Inhalation may result in nasal irritation with perforation of the septum, cough, chest pain, hoarseness, pharyngitis, and inflammation of the mouth. If ingested, metallic or garlic taste, intense thirst, nausea, vomiting, abdominal pain, diarrhea, and cardiovascular arrhythmias (heartbeat irregularities) may occur. Symptoms generally occur within 30 minutes, but may be delayed for several hours if ingested with food. Acute poisoning may result in acute hemolysis (breakdown of red blood cells).
**Chronic Effects:** Chronic symptoms include weight loss, hair loss, nausea, and diarrhea alternating with constipation, palmar and plantar hyperkeratoses (thickening of the corneous layer of skin on palms and soles of feet), and skin eruptions, and peripheral neuritis (inflammation of the nerves). Leukemia, bone marrow depression, or aplastic anemia (dysfunctioning of blood-forming organs) may occur after chronic exposure.
**FIRST AID**
**Eyes:** Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
**Skin:** *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
**Inhalation:** Remove exposed person to fresh air and support breathing as needed.
**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
**After first aid, get appropriate in-plant, paramedic, or community medical support.**
**Physician's Note:** If emesis is unsuccessful after two doses of Ipecac, consider gastric lavage. Monitor urine arsenic level. Alkalinization of urine may help prevent disposition of red cell breakdown products in renal tubular cells. If acute exposure is significant, maintain high urine output and monitor volume status, preferably with central venous pressure line. Abdominal X-rays should be done routinely for all ingestions. Chelation therapy with BAL, followed by n-penicillamine is recommended, but specific dosing guidelines are not clearly established.

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** Notify safety personnel of spill, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against dust inhalation and contact with skin and eyes. Use nonsparking tools. With a clean shovel, scoop material into a clean, dry container and cover. Absorb liquid material with sand or noncombustible inert material and place in disposal containers. Do not release to sewers, drains, or waterways. Follow applicable OSHA regulations (29 CFR 1910.120).
**Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

**EPA Designations***
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance† (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [† per Clean Water Act, Sec. 307(a); per Clean Air Act, Sec. 112]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

**OSHA Designations‡**
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not liste[illegible]

* Designations for arsenic only.
‡ Listed as arsenic organic compounds (as As).

## Section 8. Special Protection Data

**Goggles:** Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
**Respirator:** Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
**Warning:** Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
**Other:** Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
**Ventilation:** Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PELs, ACGIH TLVs, and NIOSH REL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
**Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
**Contaminated Equipment:** Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
**Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9. Special Precautions and Comments

**Storage Requirements:** Store in closed, properly labeled, containers in a cool, well-ventilated area away from all incompatible materials (Sec. 5) and heat and ignition sources. Protect containers from physical damage.
**Engineering Controls:** Avoid inhalation or ingestion of dust and fumes, and skin or eye contact. Practice good personal hygiene and housekeeping procedures. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program with training, maintenance, inspection, and evaluation. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Provide preplacement and annual physical examination with emphasis on the skin, respiratory system, and blood.

**Transportation Data (49 CFR 172.101, .102)**

**DOT Shipping Name:** Arsenic, solid
**DOT Hazard Class:** Poison B
**ID No.:** UN1558
**DOT Label:** Poison
**DOT Packaging Requirements:** 173.366
**DOT Packaging Exceptions:** 173.364

**IMO Shipping Name:** Arsenic, metallic
**IMO Hazard Class:** 6.1
**IMO Label:** Poison
**IMDG Packaging Group:** II
**ID No.:** UN1558

***MSDS Collection* References:** 7, 26, 38, 53, 73, 85, 87, 88, 89, 100, 103, 109, 123, 124, 126, 127, 130, 136, 138
**Prepared by:** MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

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## Section 1. Material Identification



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HMIS
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**Asbestos and Asbestos-containing Materials Description:** Asbestos is a generic term applied to many naturally occurring, hydrated silicates (minerals) found in rock which separate into flexible fibers when crushed or processed. Commercially important forms are amosite, anthrophyllite (mined and used only in Finland), chrysotile, and crocidolite. Other types include tremolite and actinolite. Most widely used in US industry is chrysotile, a fibrous form of serpentine. Since asbestos is insensitive to chemical attack and incombustible, there are over 2000 uses as processed fiber. It is added to such diverse materials as cement, vinyl, plaster, asphalt, and cotton, although due to its health hazards other materials are now replacing it wherever possible. Its use is now limited to products that bind fibers within the product. The largest use of asbestos is in asbestos cement for pipes in water supply, sewage disposal, and irrigation systems; ducts; and flat and corrugated sheets for a wide variety of construction applications. Other uses include fire-resistant textiles, floor tiles, underlayment and roofing papers, friction materials (brake linings), reinforcing filler in elastomers for packing and gaskets, reinforcing pigment in surface coatings and sealants, thermal and electrical insulation media, as a component of taping compound and industrial talcs, and as filler in industrial greases. About 98% of crocidolite is used in production of asbestos cement pipe. Between 1950 and 1972 asbestos was used as spray insulation in buildings, but OSHA now prohibits spray application of actinolite, anthophyllite, asbestos, or tremolite (29 CFR 1910.1001).
**Other Designations:** CAS No. 12172-73-5, amosite, brown asbestos; CAS No. 1332-21-4, asbestos; CAS No. 12001-29-5, chrysotile, white asbestos; CAS No. 12001-28-4, crocidolite, blue asbestos; Ascarite; earth flax; mountain cork; stone flax.
**Molecular Formulas:** Amosite, $(FeMg)SiO_3$; anthophyllite, $(MgFe)_7Si_8O_{22}(OH)_2$; chrysotile, $3MgO{\bullet}2SiO_2{\bullet}H_2O$; crocidolite, $NaFe(SiO_3)_2{\bullet}FeSiO_3{\bullet}H_2O$; tremolite, $Ca_2Mg_5Si_8O_{22}(OH)_2$.
**Manufacturer:** Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.
**Cautions:** Asbestos causes three specific diseases: asbestosis (fibrous lung scarring), lung cancer, and mesothelioma (cancer of the chest lining and abdominal cavities). Prevent or maintain exposures at the lowest feasible level.

## Section 2. Ingredients and Occupational Exposure Limits

| | 1989 OSHA PELs* | | | 1990-91 ACGIH TLVs | 1988 NIOSH REL |
|---|---|---|---|---|---|
| **Asbestos** | **TWA:** 0.2 f/cc† | **Action Level TWA:** 0.1 f/cc | **Excursion Limit:** 1.0 f/cc‡ | **TWA:** 2.0 f/cc§ | 0.1 f/cc |
| **Amosite** | 0.2 f/cc | 0.1 f/cc | 1.0 f/cc | 0.5 f/cc | 0.1 f/cc |
| **Chrysotile** | 0.2 f/cc | 0.1 f/cc | 1.0 f/cc | 2.0 f/cc | 0.1 f/cc |
| **Crocidolite** | 0.2 f/cc | 0.1 f/cc | 1.0 f/cc | 0.2 f/cc | 0.1 f/cc |

**1985-86 Toxicity Data for Asbestos (CAS No. 1332-21-4)****
Human, inhalation, $TC_{Lo}$: 1.2 fb/cc, continuous exposure over 19 years. Toxic to lungs.
* OSHA has proposed a lower asbestos exposure limit of 0.1 f/cc as an 8-hr TWA (*Industrial Safety and Hygiene News*, 8/90).
† Fiber/cm³
‡ Average over a 30-min sampling period.
§ As determined by membrane filter method at 400 to 450X magnification (4-mm objective) phase contrast illumination. Fibers longer than 5 µg and with an aspect ratio ≥ 3:1 (ACGIH).
** See NIOSH, *RTECS* (CI6475000), for additional toxicity data.

## Section 3. Physical Data

**Melting Point:** Decomposes
**Water Solubility:** Insoluble (breaks down slowly in hot water)
**Molecular Weight:** Varies with asbestos form (Sec. 1)
**Appearance and Odor:** White or greenish (chrysotile), blue (crocidolite), or gray-green (amosite) fibrous, odorless solids.

## Section 4. Fire and Explosion Data

| Flash Point: None reported | Autoignition Temperature: None reported | LEL: None rpeorted | UEL: None reported |
|---|---|---|---|

**Extinguishing Media:** Asbestos is nonflammable. Use dry chemcial, $CO_2$, water spray, or regular foam. Do not scatter spilled material with high-pressure water streams. **Special Fire-fighting Procedures:** Isolate hazard area and deny entry. Since there may be airborne asbestos fibers, 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 limited protection. If feasible, remove containers from fire area. Avoid dust generation. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Develop decontamination procedures for protective clothing and equipment.

## Section 5. Reactivity Data

**Stability/Polymerization:** Asbestos is inert under ordinary room temperature and heated use conditions. It is heat resistant, but decomposes and alters its microscopic fiber structure above 600 °C (1112 °F). Chrysotile dehydroxylates at 1112 to 1436 °F (600 to 780 °C); the "asbestos anhydride" in turn breaks down to a mixture of silica ($SiO_2$) and fosterite ($Mg_2SiO_4$) at 1472 to 1562 °F (800 to 850 °C). Above 1832 °F (1000 °C) magnesium pyroxenes form and melt at ~2642 °F (1450 °C). **Chemical Incompatibilities:** Strong acids can attack chrysotile and rapidly extract its MgO and $H_2O$ content; glacial acetic acid can decompose it. Hot water slowly breaks down chrysotile. Like other asbestos forms, it resists strong alkali (5M NaOH at least up to 100 °C).

## Section 6. Health Hazard Data

**Carcinogenicity:** The NTP, IARC, OSHA, and ACGIH list asbestos as a human carcinogen. **Summary of Risks:** Asbestos may cause 1) asbestosis, 2) lung cancer, 3) mesothelioma, 4) pleural plaques, and 5) several other forms of cancer. *Asbestosis* is fibrosis (scarring) of lung tissue after many years of high-level occupational exposure. Scarring may be progressive even after exposure ceases. Even though detectable in lungs of a high proportion of adults in industrialized areas, asbestosis does not result from lower level environmental exposure. Its symptoms range from mild shortness of breath and dry cough to severe disabling breathlessness, heart failure, and ultimately death. Lung scarring can be seen on X-ray and alterations in lung function can be detected with spirometry (a medical test). Examination typically detects rales (crackling sounds in lungs). Severe cases may have cyanosis (bluish skin discoloration) and clubbing of fingertips. *Lung cancer* can result from lower exposure levels than asbestosis, but also takes many years to develop. Smokers exposed to asbestos are at 5 to 10X higher risk than exposed nonsmokers. *Mesothelioma* is a very aggressive cancer of the pleura (lining around the lungs) or peritoneum (lining of the abdomen), and develops after decades of (sometimes low level) exposure. Symptoms may include chest and abdominal pain, weight loss, and/or shortness of breath, with death within 2 years of diagnosis. *Pleural plaques* are thickenings, sometimes with calcium deposits, of the lungs's lining and may be seen on X-ray. While not associated specifically with health effects, they indicate significant exposure. *Other sites of cancer* include larnyx (vocal cords), portions of digestive tract, and possibly the kidney. Asbestos's toxicity depends on fiber type (crocidolite > amosite > chrysotile), size (longer > shorter), shape (long, thin needle-like > curly), and solubility. Health effects depend on dose (exposure concentration and duration), smoking habits, and individual susceptibility. Prevent or maintain exposures at lowest feasible level.

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## Section 6. Health Hazard Data, *continued*

**Medical Conditions Aggravated by Long-Term Exposure:** Long-term, high-level exposure may aggravate any chronic lung (asthma, emphysema, bronchitis) or heart condition. **Target Organs:** Respiratory system; possibly digestive system. **Primary Entry Routes:** Inhalation, ingestion, dermal contact. **Acute Effects:** Nose, throat, skin and eye irritation are possible with high exposure. **Chronic Effects:** Asbestosis, lung cancer, and mesothelioma typically develop decades (20 to 40 years) after exposure begins, but may occur sooner. **FIRST AID** *Emergency personnel should protect against asbestos exposure.* **Eyes:** Do not rub. Gently lift eyelids and flush with flooding amounts of water. **Skin:** Shower with water and soap. Wet contaminated clothing prior to removal and seal in a plastic bag for disposal as hazardous waste. If rash develops, consult physician. **Inhalation:** Remove to fresh air. Clean any fibers from nose and mouth. Encourage victim to cough, spit, and blow nose to remove fibers. **Ingestion:** Induce vomiting *only* if awake and alert. Consult a physician. **After first aid, consult medical care provider.** **Note to Physicians:** Asbestos diagnosis is based on chest X-ray with an abnormal ILO "B" reading (small irregular opacities), rales, restrictive pattern spirometry, adequate exposure history, and symptoms. Consider pneumovax, annual flu shot, and other supportive treatment as needed.

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** Notify safety personnel and evacuate all unnecessary personnel. Cleanup personnel should protect against dust inhalation and skin or eye contact. Avoid dust generation, blowing, dry brushing, and dry mopping. Provide HEPA-filtered (high-efficiency particulate air) portable ventilation systems. Use wet cleaning methods or approved HEPA vacuum cleaning system to pick up spills. The techniques used must collect particulate without dispersing dust into air. Place waste in *properly labeled* dust-tight containers or sealed, heavy-gauge, impervious plastic bags 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 CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per Clean Water Act, Sec. 307(a); Clean Air Act, Sec. 112]
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA Extremeley Hazardous Substance (40 CFR 355): Not listed

**OSHA Designations**
Listed as Air Contaminant (29 CFR 1910.1000, Table Z-1-A, Z-3)

## Section 8. Special Protection Data

Note: *Do not substitute personal protective clothing or equipment for proper handling and engineering controls.* **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 airborne concentration of asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals not in excess of 2 f/cc (10 X PEL), use a half-mask air-purifying respirator, other than a disposable respirator, equipped with high-efficiency filters; not in excess of 10 f/cc (50 X PEL), a full facepiece air-purifying respirator equipped with high-efficiency filters; not in excess of 20 f/cc (100 X PEL), any powered air-purifying respirator equipped with high-efficiency filters or any supplied-air respirator operated in continuous flow mode; not in excess of 200 f/cc (1000 X PEL), a full facepiece supplied-air respirator operated in pressure-demand mode; greater than 200 f/cc (>1,000 X PEL) or unknown concentration, a full facepiece supplied-air respirator operated in pressure-demand mode and equipped with an auxillary positive-pressure self-contained breathing apparatus (29 CFR 1910.1001). *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 exhaust ventilation and dust collection 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 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. Never enter lunchroom facilities or leave workplace wearing clothing or equipment worn during workshift. Separate contaminated work clothes from street clothes. *If proper hygiene is not rigorously followed, family members can be exposed to asbestos fibers.* Place contaminated protective devices or work clothing in labeled, impermeable, and sealed containers or bags. Do not remove asbestos from clothing by blowing or shaking. Launder contaminated clothing before wearing. Inform laundering service of asbestos-contaminated clothing and of asbestos' potential harmful effects (29 CFR 1910.1001). **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using asbestos, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9. Special Precautions and Comments

**Storage Requirements:** Store in closed (dust-tight) containers or heavy-gauge impervious plastic bags in a clean, secure area protected from physical damage. Do not open containers that can release asbestos dust without providing proper enclosure or control measure. **Engineering Controls:** Educate workers about asbestos's and asbestos-containing materials' hazards. Inform employees of asbestos standard (29 CFR 1910.1001). Exposure to asbestos, tremolite, anthophyllite, and actinolite in construction work is covered by 29 CFR 1926.58. ["OSHA is proposing an expanded requirement for a trained 'competent person' to ensure compliance with the standard on all construction operations involving asbestos, and requiring more stringent housekeeping to remove asbestos in general industry." (*Industrial Safety and Hygiene News*, 8/90).] Instruct employees in proper practices for handling asbestos-containing materials and correct use of protective equipment. Prevent or minimize asbestos exposure. Regulate areas where exposure in excess of the PEL is likely. Post warning signs in all regulated areas (see legend below). Work with asbestos only in a sufficient wet state to prevent emission of airborne fibers. Practice good personal hygiene and housekeeping procedures. Do not substitute personal protective equipment for proper handling and engineering controls. If exposures exceed the PEL, ensure employees wear appropriate protective clothing. Inhaling or ingesting asbestos fibers from contamined clothing or skin can be hazardous. Do not allow dusts and asbestos-containing wastes to accumulate. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Monitor work areas that expose employees to airborne concentrations at or above the action level (Sec. 2). Whenever production, process, control equipment, personnel, or work practices change, institute new monitoring. **Other Precautions:** Medical surveillance is required for all employees possibly exposed at or above the action level. Provide preplacement medical examination that includes complete medical and work history, complete physical examination that emphasizes respiratory and cardiovascular systems and digestive tract, the respiratory disease standardized questionnaire, a posterior-anterior 14" x 17" chest roentgenogram, and pulmonary function tests [FVC and FEV(1)]. Annual periodic medical examinations shall include all these elements and an abbreviated questionnaire. If it is 10+ years since first asbestos exposure, an individual should have a chest roentogram: every 5 years (ages 15 to 35), every 2 years (ages 35 to 45), every year (age 45+). Within 30 days of employment termination, an individual should receive a periodic medical examination with the elements listed above. Keep medical surveillance records for duration of employment, plus 30 years.

**Transportation Data (49 CFR 172.101, .102)**
**DOT Shipping Name:** Asbestos
**DOT Hazard Class:** ORM-C
**ID No.:** -
**DOT Label:** None
**DOT Packaging Exceptions:** 173.1090
**DOT Packaging Requirements:** 173.1090
**Other Requirements:** Stow and handle to avoid airborne particle
**IMO Shipping Name:** Asbestos, blue; asbestos, white
**IMO Hazard Class:** 9
**ID No.:** UN2212, UN2590
**IMO Label:** None
**IMDG Packaging Group:** II, III

DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED IN THIS AREA

*MSDS Collection* **References:** 2-4, 6, 12, 14, 20, 26, 32, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138-140, 142, 143, 146, 148, 152, 153, 156-158
**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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## 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.

R 1
I 4
S 2
K 1

Genium

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

## Section 2. Ingredients and Occupational Exposure Limits

Beryllium and compounds, ca 100%

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

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

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

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

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

## Section 3. Physical Data

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

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

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

## Section 4. Fire and Explosion Data

**Flash Point:** None reported **Autoignition Temperature:** Powder, ca 1200 °F (649 °C) **LEL:** None reported **UEL:** None reported
**Extinguishing Media:** *Never* use water or $CO_2$. Instead, smother the fire with an approved dry-powder extinguisher. Sand, graphite powder, and sodium chloride are also recommended.
**Unusual Fire or Explosion Hazards:** Beryllium can be a moderate fire hazard if exposed to flame. The hazards increase as particulate size decreases. A beryllium dust cloud can be explosive (areas where dusting may occur require Class 2, Group E electrical services, 29 CFR 1910.309). This material's combustion products are *highly toxic.*
**Special Fire-fighting Procedures:** Fire fighters should use full protective clothing, eye protection, and a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode. After exposure to a beryllium fire, they should clean equipment and bathe carefully.

## Section 5. Reactivity Data

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

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

## Section 6. Health Hazard Data

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

*Continue on next page*

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## Section 6. Health Hazard Data, continued

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

**FIRST AID**

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

**After first aid, get appropriate in-plant, paramedic, or community medical attention and support.** Watch for signs of respiratory deterioration, and use oxygen as needed.

## Section 7. Spill, Leak, and Disposal Procedures

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

**OSHA Designations**

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

**EPA Designations**

RCRA Hazardous Waste (40 CFR 261.33): Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per RCRA, Sec. 3001; per Clean Water Act, Sec. 307(a), 112]

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

SARA Toxic Chemical (40 CFR 372.65): Not listed

## Section 8. Special Protection Data

**Goggles:** Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Wear a NIOSH-approved respirator for emergency and nonroutine use in concentrations above the 8-hr, 2-$\mu g/m^3$ TWA. For any time period, a half-mask, air-purifying respirator with a high-efficiency filter is suitable for concentrations as high as 25-$\mu g$ $Be/m^3$ (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 $\mu g$ $Be/m^3$. A full facepiece, air-purifying respirator with a high-efficiency filter is suitable for concentrations up to 100 $\mu g$ $Be/m^3$. A powered, air-purifying respirator equipped with a high-efficiency filter, operating in the positive-pressure mode, is suitable for concentrations up to 1000 $\mu g$ $Be/m^3$. An SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode is suitable for concentrations above 1000 $\mu g$ $Be/m^3$. 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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## 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.

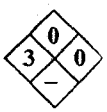
*Powder*

| 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, and 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)...

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## Section 6. Health Hazard Data, *continued*

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

**FIRST AID**

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

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

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

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

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

## Section 7. Spill, Leak, and Disposal Procedures

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

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

**EPA Designations**

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

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

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

Listed as a SARA Toxic Chemical (40 CFR 372.65)

**OSHA Designations**

Listed as an Air Contaminant (29 CFR 1910.1027)

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

## Section 8. Special Protection Data

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

## Section 9. Special Precautions and Comments

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

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

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

**Transportation Data (49 CFR 172.101)**

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

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## Section 1 - Chemical Product and Company Identification 48

**Product/Chemical Name:** Cesium Hydroxide
**Chemical Formula:** CsOH
**CAS Number:** 21351-79-1
**Synonyms:** cesium hydrate
**Derivation:** Produced by electrolysis of cesium salts or by adding barium hydroxide to an aqueous solution of cesium sulfate.
**General Use:** Used in storage battery electrolytes for sub-zero temperatures, in color photography, and as a catalyst in the polymerization of cyclic siloxanes.
**Vendors:** Consult the latest *Chemical Week Buyers' Guide.* (73)

## Section 2 - Composition / Information on Ingredients

Cesium hydroxide, ca 100 %wt

| OSHA PEL | ACGIH TLV | NIOSH REL | DFG (Germany) MAK |
|---|---|---|---|
| *Vacated 1989 Final Rule Limit* 8-hr TWA: 2 mg/m$^3$ | TWA: 2 mg/m$^3$ | 10-hr TWA: 2 mg/m$^3$ | None established |

## Section 3 - Hazards Identification

**☆☆☆☆☆ Emergency Overview ☆☆☆☆☆**

Cesium hydroxide exists as colorless, white, or yellowish crystals. It readily absorbs moisture from air and surfaces. It is the strongest known base and is highly corrosive to all body surfaces.

| Wilson Risk Scale | |
|---|---|
| R | 1 |
| I | 3 |
| S | 4 |
| K | 1 |

| HMIS | |
|---|---|
| H | 3 |
| F | 0 |
| R | 0 |

PPE*
*Sec. 8

### Potential Health Effects

**Primary Entry Routes:** Inhalation, skin and eye contact.
**Target Organs:** Eyes, skin, respiratory tract.
**Acute Effects:** Because cesium hydroxide is used in such small quantities, toxicity data for industrial exposures is little or non-existent. However, it is becoming more widely used which may result in future toxic exposures. Because cesium is similar to lithium, it is expected that overexposure may result in central nervous system effects.
**Inhalation:** Inhalation of dusts can cause severe irritation and possible burns of the respiratory tract. The severity is due to cesium hydroxide's ability to extract moisture from the mucous membranes.
**Eye:** Corrosive. May cause permanent damage.
**Skin:** Highly irritating and can be corrosive, especially if skin is moist.
**Ingestion:** Severe irritation and possible burns of the gastrointestinal tract.
**Carcinogenicity:** ACGIH, IARC, NTP, and OSHA do not list cesium hydroxide as a carcinogen.
**Medical Conditions Aggravated by Long-Term Exposure:** None reported.
**Chronic Effects:** None reported.
**Other:** Cesium hydroxide has been shown not to be a sensitizer in animal studies.

## 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. Gently wash exposed area with soap and water. For reddened or blistered skin, consult a physician.
**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting due to the corrosive nature of cesium hydroxide. Vomiting can compound the damage to the gastrointestinal tract and pose additional respiratory damage if aspirated.
***After first aid, get appropriate in-plant, paramedic, or community medical support.***
**Note to Physicians:** Treat alkali burns as for thermal burns. Use copius irrigation.

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## Section 5 - Fire-Fighting Measures

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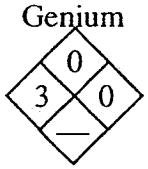


**Flash Point:** Noncombustible.
**Autoignition Temperature:** Noncombustible.
**LEL:** None reported.
**UEL:** None reported.
**Flammability Classification:** Noncombustible solid.
**Extinguishing Media:** Use agents suitable for surrounding fire. Be aware that water may be used, but that it can create a large amount of heat.
**Unusual Fire or Explosion Hazards:** Use agents suitable for surrounding fire. If water is used, flooding amounts are needed to minimize the exothermic reaction with cesium hydroxide. Material may become molten.
**Hazardous Combustion Products:** None reported.
**Fire-Fighting Instructions:** Do not release runoff from fire control methods to sewers or waterways.
**Fire-Fighting Equipment:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.

## Section 6 - Accidental Release Measures

**Spill /Leak Procedures:** Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel must protect against inhalation and skin/eye contact.
**Small Spills:** Carefully scoop up or vacuum (with appropriate filter) and place in suitable containers.
**Large Spills**
**Containment:** Flush spill to containment area with flooding quantities of water (enough to prevent exothermic reaction with cesium hydroxide) for later reclamation or disposal. Do not release into sewers or waterways.
**Cleanup:** Damp mop any residue.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Use only in a fume hood and with appropriate PPE.
**Storage Requirements:** Store in a cool, dry, well-ventilated area. Keep containers tightly closed to prevent absorption of moisture and exposure to carbon dioxide. It must be stored in platinum or silver containers. Glass containers are not suitable due to reaction with glass. Store away from water sources and incompatibles (Sec. 10).

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Enclose processes where possible to prevent dust dispersion into work areas.
**Ventilation:** Provide general or local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]
**Administrative Controls:** Consider preplacement and periodic medical exams (including lung function tests) of exposed workers, especially those exposed to the action level (1 mg/m$^3$) or above.
**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. High-efficiency particulate respirators may be necessary for protection. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
**Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Polyvinyl chloride is considered appropriate PPE material. 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 cesium hydroxide from your shoes and clean personal protective equipment.
**Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using cesium hydroxide, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.


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## Section 9 - Physical and Chemical Properties

**Physical State:** Solid
**Appearance and Odor:** Colorless, white, or yellowish crystals.
**Vapor Pressure:** ~0 mm Hg at 68 °F (20 °C)
**Formula Weight:** 149.92
**Density ($H_2O$=1, at 4 °C):** 3.68 g/mL
**Water Solubility:** Highly soluble; 395% at 59 °F (15 °C)
**Other Solubilities:** Soluble in alcohol.
**Melting Point:** 521.6 °F (272 °C)

## Section 10 - Stability and Reactivity

**Stability:** Cesium hydroxide is stable at room temperature in closed containers under normal storage and handling conditions.
**Polymerization:** Hazardous polymerization does not occur.
**Chemical Incompatibilities:** Glass, carbon dioxide, water, strong acids (hydrochloric, sulfuric, nitric), and metals (aluminum, lead, zinc, tin). Contact with wet metals can evolve highly flammable and explosive hydrogen gas.
**Conditions to Avoid:** Exposure to water and other incompatibles.
**Hazardous Decomposition Products:** None reported.

## Section 11 - Toxicological Information

### Toxicity Data:*

**Eye Effects:**
Rabbit, eye: 5 mg/5 min rinse caused severe irritation.

**Skin Effects:**
Rabbit, skin: 5 mg/24 hr caused mild irritation.

**Acute Oral Effects:**
Rat, oral, $LD_{50}$: 570 mg/kg caused somnolence, muscle contraction or spasticity, and respiratory changes.
Mouse, oral, $LD_{50}$: 800 mg/kg caused tetany.

* See NIOSH, *RTECS* (FK9800000), for additional 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:** Cesium hydroxide, solid*; Cesium hydroxide, solution†
**Shipping Symbols:** –
**Hazard Class:** 8
**ID No.:** UN2682*, UN2681†
**Packing Group:** II
**Label:** Corrosive
**Special Provisions (172.102):** –*; B2, T8†

**Packaging Authorizations**
**a) Exceptions:** 173.154
**b) Non-bulk Packaging:** 173.212*; 202†
**c) Bulk Packaging:** 173.240*; 242†

**Quantity Limitations**
**a) Passenger, Aircraft, or Railcar:** 15 kg*; 1 L†
**b) Cargo Aircraft Only:** 50 kg*; 30 L†

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

## Section 15 - Regulatory Information

**EPA Regulations:**
Classified as a RCRA Hazardous Waste (40 CFR 261.22): Characteristic of Corrosivity, D002
Listed as a "Unlisted Hazardous Waste, Characteristic of Corrosivity" CERCLA Hazardous Substance (40 CFR 302.4) per RCRA, Sec. 3001
CERCLA Reportable Quantity (RQ), 100 lb (45.4kg)
SARA Toxic Chemical (40 CFR 372.65): Not listed
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed

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**OSHA Regulations:**
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

## Section 16 - Other Information

**References:** 73, 103, 124, 136, 176, 190, 197, 201, 203, 209

**Prepared By** ..... M Gannon, BA
**Industrial Hygiene Review** ..... PA Roy, MPH, CIH
**Medical Review** ..... J Brent, MD, PhD

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**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/m³ | TLV-TWA: 0.5 mg/m³ | 8-hr TWA (for chromium metal and insoluble salts): 1 mg Cr/m³ | Rat, implant, $TD_{Lo}$: 1200 µg/kg body weight administered intermittently over six weeks |

* This TLV is applicable to $Cr^{+2}$ and $Cr^{+3}$ compounds. For water soluble and water-insoluble $Cr^{+6}$, the 8-hr TWA is 0.05 mg $Cr^{+6}/m^3$. 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/m³; for noncarcinogenic $Cr^{+6}$ compounds (including chromic acid), the RELs (10-hr TWAs) are 25 µg/m³ and 50 µg/m³ (15-min ceiling ). The noncarcinogenic compounds include mono- and dichromates of hydrogen, cesium, sodium, lithium, potassium, rubidium, ammonia, and $Cr^{+6}$ (chromic acid anhydride). Any and all $Cr^{+6}$ materials excluded from the noncarcinogenic group above are carcinogenic $Cr^{+6}$ compounds.
‡ See NIOSH, *RTECS* (GB4200000), for additional data with references to tumorigenic effects.

## Section 3. Physical Data

**Boiling Point:** 4788 °F (2642 °C)
**Melting Point:** 3452 °F (1900 °C)
**Vapor Pressure:** 1 mm Hg at 2941 °F (1616 °C)
**Vapor Density (Air = 1):** 1.79
**Atomic Weight:** 51.996 g/mol
**Specific Gravity ($H_2O$ = 1 at 39 °F (4 °C)):** 7.2 at 68 °F (20 °C)
**Water Solubility:** Insoluble

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

## Section 4. Fire and Explosion Data

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

**Extinguishing Media:** Use dry chemical or sand.
**Unusual Fire or Explosion Hazards:** Particle size and dispersion in air determine reactivity. Chromium powder explodes spontaneously in air, while chromium dust suspended in $CO_2$ is ignitable and explosive when heated.
**Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

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

## Section 5. Reactivity Data

**Stability/Polymerization:** Chromium is stable when properly handled and stored. Hazardous polymerization cannot occur.
**Chemical Incompatibilities:** Chromium reacts readily with dilute, not nitric, acids to form chromous salts. It is soluble in acids (not nitric) and strong alkalis. Its powder is incompatible with strong oxidizing agents, including high $O_2$ concentration. Evaporation of mercury (Hg) from Cr amalgam leaves pyrophoric chromium. Finely divided Cr attains incandescence with nitrogen oxide, potassium chlorate, and sulfur dioxide. Molten lithium at 18 °C severely attacks Cr. Fused ammonium nitrate below 200 °C reacts explosively and may ignite or react violently with bromine pentafluoride.
**Hazardous Products of Decomposition:** Thermal oxidative decomposition of Cr can produce toxic chromium oxide fumes.

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## Section 6. Health Hazard Data

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

**Summary of Risks:** When ingested chromium is a human poison, with gastrointestinal (GI) effects. Chromium 3 ($Cr^{+3}$) compounds show little or no toxicity. Less soluble chromium 6 ($Cr^{+6}$) compounds are suspected carcinogens and severe irritants of the larynx, nasopharynx, lungs, and [illegible] (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

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## Section 1. Material Identification

**Coal Tar Creosote (molecular formula varies with purity) Description:** Three main derivations: by distillation of coal tar produced by high-temperature carbonization of bituminous coal; by mixing strained naphthalene oil, wash oil, and strained or light anthracene oil; as a by-product of conventional coal coking. It typically contains up to 160 chemicals, mainly aromatic compounds such as phenol, pyrol and pyridine. Used mainly as a wood preservative for railroad ties, poles, fence posts, marine pilings, and other lumber for outdoor use; as a water-proofing agent, fuel oil constituent, frothing agent for mineral separation, hop defoliant, and lubricant for die molds; in manufacturing chemicals; and in medicine as an antiseptic, disinfectant, antipyretic, astringent, germicide, and styptic.
**Other Designations:** CAS No. 8001-58-9, Awpa,® brick oil, Caswell No. 225,® coal tar oil, creosote, creosote oil, creosotum, cresylic creosote, heavy oil, liquid pitch oil, naphthalene oil, Preserv-o-sote,® Sakresote,® tar oil, wash oil.
**Manufacturer:** Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.
**Cautions:** Flammable, liquid coal tar creosote is toxic by inhalation, ingestion, and skin contact. The IARC and NTP classify it as *a human carcinogen.*

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

NFPA
2 / 2 / 0 / -

HMIS
H 2
F 2
R 0
PPG†
† Sec. 8

* Skin absorption can occur with phenol, a major component of coal tar creosote.

## Section 2. Ingredients and Occupational Exposure Limits

Coal tar creosote, ca 100%

**1990 OSHA PEL**
8-hr TWA: 0.2 mg/m³*

**1990-91 ACGIH TLV**
TWA: 0.2 mg/m³*

**1987 IDLH Level**
700 mg/m³

**1990 NIOSH REL**
0.1 mg/m³ (cyclohexane extractable portion)

**1985-86 Toxicity Data†**
Rat, oral, $LD_{50}$: 725 mg/kg; toxic effects not yet reviewed
Dog, oral, $LD_{Lo}$: 600 mg/kg; toxic effects not yet reviewed
Rat, $TD_{Lo}$: 52,416 mg/kg administered during 91 days prior to mating produces reproductive effects on fallopian tubes and ovaries
Mouse, skin, $TD_{Lo}$: 99 g/kg produces tumors in skin and appendages

* As coal tar pitch volatiles.
† See NIOSH, *RTECS* (GF8615000), for additional mutation, reproductive, tumorigenic, and other toxicity data.

## Section 3. Physical Data

**Boiling Point:** 381 to 752 °F (194 to 400 °C)
**Distillation Range:** 446 to 554 °F (230 to 290 °C)
**Heat of Combustion:** -12,500 Btu/lb
**Heat of Vaporization:** 107 Btu/lb
**Molecular Weight:** Varies with purity
**Density/Specific Gravity:** 1.07 to 1.08 at 68 °F (20 °C)
**Water Solubility:** Slightly soluble

**Appearance and Odor:** Pure coal tar creosote is colorless, but the industrial product is a yellow to black oily liquid with an aromatic smoky smell and a burning caustic taste.

## Section 4. Fire and Explosion Data

| Flash Point: 165.2 °F (74 °C), CC | Autoignition Temperature: 637 °F (336 °C) | LEL: None reported | UEL: None reported |
|---|---|---|---|

**Extinguishing Media:** For small fires, use dry chemical, carbon dioxide ($CO_2$), or regular foam. For large fires, use fog or regular foam. Since water is least effective, use it as an extinguishing agent only when the preferred measures are unavailable. However, use water spray to cool fire-exposed containers.
**Unusual Fire or Explosion Hazards:** Vapors may travel to an ignition source and flash back. Containers may explode in heat of fire. Coal tar creosote presents a vapor explosion hazard indoors, outdoors, and in sewers.
**Special Fire-fighting Procedures:** Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Also, wear full protective clothing. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Immediately leave area if you hear a rising sound from venting safety device or notice any fire-caused tank discoloration. Isolate area for 1/2 mile in all directions if fire involves tank, rail car or tank truck. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Fully decontaminate or properly dispose of personal protective clothing.

## Section 5. Reactivity Data

**Stability/Polymerization:** Coal tar creosote is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
**Chemical Incompatibilities:** Creosote oil mixed with chlorosulfonic acid in a closed container causes an increase in temperature and pressure.
**Conditions to Avoid:** Avoid excessive heat and contact with chlorosulfonic acid.
**Hazardous Products of Decomposition:** Thermal oxidative decomposition of coal tar creosote can produce oxides of carbon and thick, black, acrid smoke.

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## Section 6. Health Hazard Data

**Carcinogenicity:** In 1990 reports, the IARC, NTP, and OSHA list coal tar creosote as a carcinogen.
**Summary of Risks:** Coal tar creosote is toxic by inhalation, ingestion, and skin contact. It contains a variety of hydrocarbons such as phenol and polycyclic aromatic hydrocarbons such as benzo[a]pyrene, benzanthracene, and phenol derivatives. The range of toxicity depends on the expo[illegible] concentration, amount, and duration. Effects may include irritation, burns, and several forms of cancer.
**Medical Conditions Aggravated by Long-Term Exposure:** Chronic respiratory or skin diseases.
**Target Organs:** Eyes, skin, bladder, kidneys, and respiratory system.
**Primary Entry Routes:** Inhalation, ingestion, and skin contact.
**Acute Effects:** Skin contact may cause irritation, burning, itching, redness, pigment changes, dermatitis (a rash of redness and small bumps), or burns. Photosensitization (worsening of rash with exposure to sunlight) may occur. Inhalation may be irritating to the respiratory tract. Eye contact may cause conjunctivitis (inflammation of the eye's lining), keratitis (corneal inflammation), or corneal burns with scarring. Ingestion may result in nausea, vomiting, abdominal pain, rapid pulse, respiratory distress, and shock. Systemic absorption by any route (including skin absorption) may cause trouble breathing, thready (continuous or drawn out) pulse, dizziness, headache, nausea, vomiting, salivation, and convulsions. Exposure to large doses (particularly by ingestion) may be fatal.
**Chronic Effects:** Dermatitis, skin cancer, and lung cancer.
**FIRST AID**
**Eyes:** Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* let victim rub eyes or keep them tightly closed. Consult a physician immediately.
**Skin:** *Quickly* remove contaminated clothing. Wash affected area with soap and flooding amounts of water for at least 15 min. 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. If ingested, have that *conscious* person drink 1 to 2 glasses of milk or water. *Do not induce vomiting!*
**After first aid, get appropriate in-plant, paramedic, or community medical support.**
**Note to Physicians:** Cresol may be detected in urine.

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** Notify safety personnel. Isolate hazard area, deny entry, and stay upwind of spills. Shut off all ignition sources–no flares, smoking, or flames in hazard area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. If possible with no risk, stop leak. Water spray may be used to reduce vapor but it may not prevent ignition in closed spaces. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for later disposal. For large spills, dike far ahead of liquid spill for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120).
**Environmental Degradation:** Coal tar creosote is fouling to shoreline. Ecotoxicity values are: $TL_{50}$, goldfish (*Carassius auratus*), 3.51 ppm/24 hr (60:40) mixture of creosote and coal tar; $LD_{50}$, bob white quail (*Colinus virginianus*), 1,260 ppm/8 days (60:40) mixture of creosote and coal tar.
**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 Material No. U051
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
**OSHA Designations**
Listed (as coal tar pitch volatiles) 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. 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 all skin contact. Applying a layer of petroleum jelly or lanolin castor oil ointment to the face reduces vapor contact and penetration through skin. Frequent change of protective garments is an additional protective measure.
**Ventilation:** Provide general and local exhaust ventilation systems equipped with high-efficiency particulate filters 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:*** Take particular care to avoid any contamination of drains or ventilation ducts. 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. Store coal tar creosote as close to area of use as possible to minimize transporting distance.
**Engineering Controls:** Use engineering controls to keep airborne concentrations below the OSHA PEL. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Always perform synthesis and purification procedures under a vertical ventilation hood and make regular operational safety checks. Label doors to rooms where coal tar creosote is produced, used, or stored as containing a carcinogen. Locate emergency equipment at well-marked and clearly identified stations in case emergency escape is necessary.
**Other Precautions:** Preplacement and periodic medical examinations of exposed workers emphasizing respiratory, skin, liver, and kidney disorders, including comprehensive work and medical history, physical examination, CXR, PFTs, urinalysis, LFT, and sputum cytology as the attending physician considers appropriate. Educate workers about coal tar creosote's carcinogenicity and proper handling procedures to avoid exposure.
**Other Comments:** Caution is in order when handling or sawing old creosote-treated lumber since it retains a considerable portion of creosote for up to 25 to 30 years.
**Transportation Data (49 CFR 172.101)**
**DOT Shipping Name:** Creosote
**DOT Hazard Class:** Flammable liquid
**ID No.:** UN1136
**DOT Label:** Flammable liquid

***MSDS Collection* References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 139, 140, 142, 143, 146, 148, 153, 159
**Prepared by:** M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** Mark Upfal, MD, MPH; **Edited by:** JR Stuart, MS



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# Material Safety Data Sheet

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No. 82

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

## SECTION 1. MATERIAL IDENTIFICATION

25

**Material Name:** COBALT METAL/POWDER

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

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

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

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

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| *See sect. 8 | | K - |

## SECTION 2. INGREDIENTS AND HAZARDS

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

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

## SECTION 3. PHYSICAL DATA

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

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

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

## SECTION 4. FIRE AND EXPLOSION DATA

| Flash Point and Method | Autoignition Temperature | Flammability Limits in Air % 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.

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## SECTION 6. HEALTH HAZARD INFORMATION

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

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

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

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

**FIRST AID**

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

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

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

**Ingestion:** Never give anything by mouth to someone who is unconscious or convulsing. If cobalt salts are ingested, give 1 to 2 glasses of water and induce vomiting.

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

## SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

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

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

**OSHA Designations**

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

**EPA Designations (40 CFR 302.4)**

RCRA Hazardous Waste: Not Listed

CERCLA Hazardous Substance: Not Listed

## SECTION 8. SPECIAL PROTECTION INFORMATION

**Goggles:** Always wear protective eyeglasses or chemical safety goggles. Follow the eye- and face-protection guidelines in 29 CFR 1910.133. **Respirator:** Wear a NIOSH-approved respirator per the *NIOSH Pocket Guide to Chemical Hazards* for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow the respirator guidelines in 29 CFR 1910.134. For emergency or nonroutine use (e.g., cleaning reactor vessels or storage tanks), wear an SCBA with a full facepiece operated in the pressure-demand or positive-pressure mode. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres.

**Other:** Wear impervious gloves; boots; aprons; and clean, impervious body-covering clothing to prevent any possibility of skin contact. Barrier creams may be useful to limit the effects of skin contact. **Ventilation:** Install and operate general and local ventilation systems powerful enough to maintain airborne levels of cobalt metal, dust, or fume below the OSHA PEL standard cited in section 2.

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

**Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them. Particles can adhere to contact lenses and cause corneal damage. Do *not* wear contact lenses in any work area.

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

## SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

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

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

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

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

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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.

**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.

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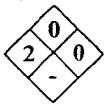


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## Section 2. Ingredients and Occupational Exposure Limits

Copper, ca 100%

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

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

## Section 3. Physical Data

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

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

## Section 4. Fire and Explosion Data

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

**Extinguishing Media:** Use extinguishing media appropriate to the surrounding fire since copper does not burn. Finely divided copper burns in air, and in extreme cases ignites spontaneously.

**Unusual Fire or Explosion Hazards:** Liquid copper explodes on contact with water. High concentrations of fine copper particles in the air may present an explosion hazard.

**Special Fire-fighting Procedures:** Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and a fully encapsulating suit.

## Section 5. Reactivity Data

**Stability/Polymerization:** Copper is stable at room temperature in closed containers under normal storage and handling conditions. However, on long standing, a white, highly explosive peroxide deposit may form. Copper's vapors are uninhibited and may form polymers in vents and flame arresters.

**Chemical Incompatibilities:** Copper reacts violently with ammonium nitrate, bromates, iodates, chlorates, ethylene oxide, hydrazoic acid, potassium oxide, dimethyl sulfoxide + trichloroacetic acid, hydrogen peroxide, sodium peroxide, sodium azide, sulfuric acid, hydrogen sulfide + air, and lead azide. A potentially explosive reaction occurs with actylenic compounds. Copper ignites on contact with chlorine, fluorine [above 250 °F (121 °C)], chlorine trifluoride, and hydrazinium nitrate [above 158 °F (70 °C)]. It is also incompatible with 1-bromo-2-propyne; an incandescent reaction occurs with potassium dioxide.

**Conditions to Avoid:** Avoid prolonged exposure to air and moisture. On exposure to moist air, copper slowly converts to the carbonate.

**Hazardous Products of Decomposition:** Thermal oxidative decomposition of copper can produce metallic oxides (copper fumes).

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## Section 6. Health Hazard Data

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

## Section 7. Spill, Leak, and Disposal Procedures

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

## Section 8. Special Protection Data

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

## Section 9. Special Precautions and Comments

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

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

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## Section 1. Material Identification



**Diesel Fuel Oil No. 2-D Description:** Diesel fuel is obtained from the middle distillate in petroleum separation; a distillate oil of low sulfur content. It is composed chiefly of unbranched paraffins. Diesel fuel is available in various grades, one of which is synonymous with fuel oil No. 2-D. This diesel fuel oil requires a minimum Cetane No. (efficiency rating for diesel fuel comparable to octane number ratings for gasoline) of 40 (ASTM D613). Used as a fuel for trucks, ships, and other automotive engines; as mosquito control (coating on breeding waters); and for drilling muds.

**Other Designations:** CAS No. 68334-30-5, diesel fuel.

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

**Cautions:** Diesel fuel oil No. 2-D is a skin irritant and central nervous depressant with high mist concentrations. It is an environmental hazard and moderate fire risk.

| | |
|---|---|
| R | 1 |
| I | - |
| S | 2 |
| K | 2 |

NFPA

HMIS
H 0
F 2
R 0
PPG*
* Sec. 8

## Section 2. Ingredients and Occupational Exposure Limits

Diesel fuel oil No. 2-D*

| 1989 OSHA PEL | 1990-91 ACGIH TLV | 1988 NIOSH REL | 1985-86 Toxicity Data‡ |
|---|---|---|---|
| None established | Mineral Oil Mist<br>TWA: 5 mg/m³†<br>STEL: 10 mg/m³ | None established | Rat, oral, $LD_{50}$: 9 g/kg produces gastrointestinal (hypermotility, diarrhea) effects |

* Diesel fuel No. 2-D tends to be low in aromatics and high in paraffinics. This fuel oil is complex mixture of: 1) >95% paraffinic, olefinic, naphthenic, and aromatic hydrocarbons, 2) sulfur (<0.5%), and 3) benzene (<100 ppm). [A low benzene level reduces carcinogenic risk. Fuel oils can be exempted under the benzene standard (29 CFR 1910.1028)]. Although low in the fuel itself, benzene concentrations are likely to be much higher in processing areas.
† As sampled by nonvapor-collecting method.
‡ Monitor NIOSH, *RTECS* (HZ1800000), for future toxicity data.

## Section 3. Physical Data

**Boiling Point Range:** 340 to 675 °F (171 to 358 °C)
**Viscosity:** 1.9 to 4.1 centistoke at 104 °F (40 °C)
**Specific Gravity:** <0.86
**Water Solubility:** Insoluble

**Appearance and Odor:** Brown, slightly viscous liquid.

## Section 4. Fire and Explosion Data

| Flash Point: 125 °F (52 °C) min. | Autoignition Temperature: >500 °F (932 °C) | LEL: 0.6% v/v | UEL: 7.5% v/v |
|---|---|---|---|

**Extinguishing Media:** Use dry chemical, carbon dioxide, or foam to fight fire. Use a water spray to cool fire exposed containers. Do not use a forced water spray directly on burning oil since this will scatter the fire. Use a smothering technique for extinguishing fire.

**Unusual Fire or Explosion Hazards:** Diesel fuel oil No. 2-D is a OSHA Class II combustible liquid. Its volatility is similar to that of gas oil. Vapors may travel to a source of ignition 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 and full protective clothing. If feasible, remove containers from fire. Be aware of runoff from fire control methods. Do not release to sewers or waterways due to pollution and fire or explosion hazard.

## Section 5. Reactivity Data

**Stability/Polymerization:** Diesel fuel oil No. 2-D is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

**Chemical Incompatibilities:** It is incompatible with strong oxidizing agents; heating greatly increases the fire hazard.

**Conditions to Avoid:** Avoid heat and ignition sources.

**Hazardous Products of Decomposition:** Thermal oxidative decomposition of diesel fuel oil No. 2-D can produce various hydrocarbons and hydrocarbon derivatives, and other partial oxidation products such as carbon dioxide, carbon monoxide, and sulfur dioxide.

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## Section 6. Health Hazard Data

**Carcinogenicity:** Although the IARC has not assigned an overall evaluation to diesel fuels as a group, it has evaluated occupational exposures in petroleum refining as an IARC probable human carcinogen (Group 2A). It has evaluated distillate (light) diesel oils as not classifiable as human carcinogens (Group 3).

**Summary of Risks:** Although diesel fuel's toxicologic effects should resemble kerosine's, they are somewhat more pronounced due to additives such as sulfurized esters. Excessive inhalation of aerosol or mist can cause respiratory tract irritation, headache, dizziness, nausea, vomiting, and loss of coordination, depending on concentration and exposure time. When removed from exposure area, affected persons usually recover completely. If vomiting occurs after ingestion and if oil is aspirated into the lungs, hemorrhaging and pulmonary edema, progressing to renal involvement and chemical pneumonitis, may result. A comparative ratio of oral to aspirated lethal doses may be 1 pt vs. 5 ml. Aspiration may also result in transient CNS depression or excitement. Secondary effects may include hypoxia (insufficient oxygen in body cells), infection, pneumatocele formation, and chronic lung dysfunction. Inhalation may result in euphoria, cardiac dysrhythmias, respiratory arrest, and CNS toxicity. Prolonged or repeated skin contact may irritate hair follicles and block sebaceous glands, producing a rash of acne pimples and spots, usually on arms and legs.

**Medical Conditions Aggravated by Long-Term Exposure:** *None reported.*

**Target Organs:** Central nervous system, skin, and mucous membranes.

**Primary Entry Routes:** Inhalation, ingestion.

**Acute Effects:** Systemic effects from ingestion include gastrointestinal irritation, vomiting, diarrhea, and in severe cases central nervous system depression, progressing to coma or death. Inhalation of aerosols or mists may result in increased rate of respiration, tachycardia (excessively rapid heart beat), and cyanosis (dark purplish discoloration of the skin and mucous membranes caused by deficient blood oxygenation).

**Chronic Effects:** Repeated contact with the skin causes dermatitis.

**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. If large areas of the body have been exposed or if irritation persists, get medical help immediately. Wash affected area with soap and water.

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

**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* due to aspiration hazard. Contact a physician immediately. Position to avoid aspiration.

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

**Note to Physicians:** Gastric lavage is contraindicated due to aspiration hazard. Preferred antidotes are charcoal and milk. In cases of severe aspiration pneumonitis, consider monitoring arterial blood gases to ensure adequate ventilation. Observe the patient for 6 hr. If vital signs become abnormal or symptoms develop, obtain a chest x-ray.

## Section 7. Spill, Leak, and Disposal Procedures

***Spill/Leak:*** *Notify safety personnel, evacuate area for large spills, remove all heat and ignition sources, and provide maximum explosion-proof ventilation.* Cleanup personnel should protect against vapor inhalation and liquid contact. Clean up spills promptly to reduce fire or vapor hazards. Use a noncombustible absorbent material to pick up small spills or residues. For large spills, dike far ahead to contain. Pick up liquid for reclamation or disposal. Do not release to sewers or waterways due to health and fire and/or explosion hazard. Follow applicable OSHA regulations (29 CFR 1910.120). Diesel fuel oil No. 2-D spills may be environmental hazards. Report large spills.

**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 261.21): Ignitable waste

CERCLA Hazardous Substance (40 CFR 302.4): Not listed

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

SARA Toxic Chemical (40 CFR 372.65): Not listed

**OSHA Designations**

Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

## Section 8. Special Protection Data

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

**Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, use a NIOSH-approved respirator with a mist filter and organic vapor cartridge. 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 that promote worker safety and productivity. 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:** Use and storage conditions should be suitable for a OSHA Class II combustible liquid. Store in closed containers in a well-ventilated area away from heat and ignition sources and strong oxidizing agents. Protect containers from physical damage. To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations. Use nonsparking tools and explosion-proof electrical equipment. No smoking in storage or use areas.

**Engineering Controls:** Avoid vapor or mist inhalation and prolonged skin contact. Wear protective rubber gloves and chemical safety glasses where contact with liquid or high mist concentration may occur. Additional suitable protective clothing may be required depending on working conditions. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures. Do not wear oil contaminated clothing. At least weekly laundering of work clothes is recommended. Do not put oily rags in pockets. When working with this material, wear gloves or use barrier cream.

**Transportation Data (49 CFR 172.101)**

**DOT Shipping Name:** Fuel oil

**DOT Hazard Class:** Combustible liquid

**ID No.:** NA1993

**DOT Label:** None

**DOT Packaging Exceptions:** 173.118a

**DOT Packaging Requirements:** None

***MSDS Collection* References:** 1, 6, 7, 12, 73, 84, 101, 103, 126, 127, 132, 133, 136, 143, 146

**Prepared by:** MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MD; **Edited by:** JR Stuart, MS



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*Material Safety Data Sheet Collection*

**2, 3, 7, 8-Tetrachlorodibenzo-*p*-dioxin (TCDD)** **MSDS No. 906**

Date of Preparation: 6/94

## Section 1 - Chemical Product and Company Identification 44

**Product/Chemical Name:** 2, 3, 7, 8-Tetrachlorodibenzo-*p*-dioxin (TCDD)
**Chemical Formula:** $C_{12}H_4Cl_4O_2$
**CAS No.:** 1746-01-6
**Synonyms:** dioxin; dioxine; NCI-C03714; tetrachlorodibenzodioxin; 2, 3, 7, 8-tetrachlorodibenzo(b, e)(1, 4)dioxin; 2, 3, 7, 8-tetrachlorodibenzo-1, 4-dioxin; TCDBD; TCDD; 2, 3, 7, 8-TCDD; tetradioxin
**Derivation:** TCDD is not manufactured, but is formed as a by-product of chlorobenzenes, chlorophenols, and the herbicides 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T) and 2-(2, 4, 5-trichlorophenoxy)propionic acid (Silvex) which are produced from 2, 4, 5-trichlorophenol (TCP). 2, 4, 5-T, commonly known as Agent Orange, was the defoliant used during the Vietnam War. TCP, 2, 4, 5-T and Silvex are no longer commercially produced in the U.S. As a chemical and toxicological standard, TCDD can be prepared by catalytic condensation of potassium 2, 4, 5-trichlorophenate. TCDD has been released to the environment during the incineration of chemical wastes including chlorinated benzenes, chlorophenols, and biphenyl ethers, from the improper disposal of certain chlorinated chemical wastes, in emissions from wood burning in the presence of chlorine, in accidental fires involving transformers containing PCBs, and from the use of the herbicides 2, 4, 5-T and Silvex.
**General Use:** TCDD is an extremely toxic, unwanted by-product and essentially has no beneficial uses. It may be used as a research chemical.
**Vendors:** Consult the latest *Chemical Week Buyers' Guide.* (73)

## Section 2 - Composition / Information on Ingredients

2, 3, 7, 8-Tetrachlorodibenzo-*p*-dioxin, ca 100 %wt. TCDD normally persists as a contaminant in TCP in variable amounts (0.07-6.2 mg/kg). Consequently, the concentrations of TCDD in different batches of Agent Orange varied greatly with an average concentration of about 2 ppm.

| OSHA PEL* | NIOSH REL | DFG (Germany) MAK |
|---|---|---|
| None established | Carcinogen, lowest feasible concentration. | None established |
| **ACGIH TLV** | | |
| None established | | |

* A preliminary occupational exposure limit of 0.2 ng/m$^3$ (200 pg/m$^3$) is recommended. It provides an ample margin of safety to prevent chloracne and takes into consideration the chronic effects of animal studies and accidental human exposure. [Leung HW et al; *American Industrial Hygiene Association Journal*, 49 (9): 466-74 b(1988)]

## Section 3 - Hazards Identification

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

TCDD is a colorless, crystalline solid at room temperature. It is highly toxic and a potential human carcinogen. Exposure to TCDD-contaminated materials may cause a severe and disabling acne-like rash that may persist for years (chloracne), metabolic disorders, and nervous system and liver damage. In animals, TCDD causes teratogenesis, tumorigenesis, and immunological dysfunction. Findings in humans are inconclusive, but human toxicology is under continuing investigation. Workers may be exposed to TCDD from residues from prior production or use of 2, 4, 5-T or Silvex, waste materials contaminated by TCDD, or contamination resulting from transformer fires. Take every precaution to avoid any exposure to TCDD.

**Wilson Risk Scale**
R 1
I 4
S 4*
K 1
*Skin absorption

**HMIS**
H 4†
F 1
R 0
†Chronic Effects
PPE‡
‡Sec. 8

### Potential Health Effects

**Primary Entry Routes:** Inhalation (dust),* skin contact, ingestion.
**Target Organs:** Skin, liver, and nervous system.
**Acute Effects**
**Inhalation:** Shortness of breath, headaches, fatigue, severe muscle pains, weakness, and digestive disturbance. Most symptoms develop slowly, over many days.
**Eye:** Conjunctivitis and chemical burns.
**Skin:** Chemical burns. In most cases, chloracne appears within 2 to 4 weeks after initial exposure. It consists of blackheads with small, pale-yellow cysts. In severe cases, there may be papules (red spots) or even pustules (pus-filled spots). This acne-like rash appears on the cheekbones under the eyes and behind the ears in very mild cases. With increasing severity, the rest of the face and neck are affected and the outer upper arms, chest, back, abdomen, outer thighs and genitalia may be involved in varying degrees in the worst cases. In the worst cases, lesions may be active 15 or more years after the contact has ceased. Chloracne may also appear after ingestion or inhalation. Skin fragility, hirsutism (excessive growth of hair of normal or abnormal distribution), and photosensitivity may also occur.
**Ingestion:** Nausea, vomiting, and possible pancreatitis.

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**Carcinogenicity:** The IARC, NTP, MAK , and NIOSH list TCDD as an IARC-2B (possibly carcinogenic to humans: inadequate evidence of carcinogenicity in humans but there is sufficient evidence of carcinogenicity in experimental animals), an NTP-2 (reasonably anticipated to be a carcinogen: limited evidence from studies in humans or sufficient evidence from studies in experimental animals), an MAK-A2 (unmistakably carcinogenic in animal experimentation only), and a NIOSH-X (carcinogen defined with no further categorization). OSHA does not list TCDD as a carcinogen.

**Medical Conditions Aggravated by Long-Term Exposure:** Skin, liver, nervous and endocrine system disorders.

**Chronic Effects:** Lack of energy, loss of sex drive, personality and mood changes, numbness, weakness and pain in the legs, liver damage, chloracne, and elevated blood lipids. TCDD increased the incidence of a variety of tumors in animals, but human data is inconclusive. Little is known of the human health effects (if any) as a result of long-term exposures to low concentrations.

**Comments:** The observed health effects from clinical or epidemiological studies of populations who were occupationally and non-occupationally exposed cannot be solely attributed to TCDD because of the concurrent exposure to 2, 4, 5-T and TCP and to other herbicides as well. There is no report of human exposure to TCDD alone.

* Vapor inhalation is unlikely because TCDD has a low vapor pressure.

## 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. Flush with water to remove solid particles; follow with a soap and water wash of exposed areas. 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:** For an acute exposure, obtain liver function tests, CBC, prothrombin time, serum lipids, and uroporphyrins. EMG may be useful in detecting subclinical neuropathy. Current analytical techniques to detect dioxins in human tissue specimens involve gas chromatography and mass spectrometry. Chloracne may respond to topical retinoic acid, and oral tetracyclines may help secondary pustular follicles. Resistant cases may require dermabrasion or acne surgery. Isotretinoin may be tried.

**Special Precautions/Procedures:** Emergency personnel should protect against contamination.

## Section 5 - Fire-Fighting Measures

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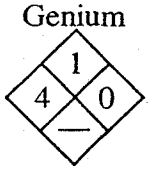


**Flash Point:** None reported.

**Autoignition Temperature:** None reported.

**LEL:** None reported.

**UEL:** None reported.

**Extinguishing Media:** Use dry chemical, carbon dioxide, water spray, or foam extinguisher.

**Unusual Fire or Explosion Hazards:** None reported.

**Hazardous Combustion Products:** Toxic fumes of chlorine.

**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 of spill, evacuate all unnecessary personnel, remove heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against skin and eye contact and dust inhalation.

**Small Spills:** Carefully collect and place in sealed containers for disposal.

**Large Spills**

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

**Cleanup:** Avoid generating dust. *Do not* sweep! Provide an organized procedure of containment, collection, and disposal of contaminated solutions and residues generated during cleanup. Provide separate facilities for decontamination of large equipment. Conduct repetitive wash/rinse cycles separately, either by using different locations or by spacing in time.

**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120). For specific recommendations, contact your Department of Environmental Protection or your regional EPA office.

## Section 7 - Handling and Storage

**Handling Precautions:** Handle with extreme caution. Take all the necessary precautions to avoid any exposure.

**Storage Requirements:** Store in tightly closed and properly labeled containers in a cool, well-ventilated area.



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## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Isolate work areas involving TCDD or TCDD-contaminated materials.
**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 examinations with emphasis on the skin, liver, nervous and endocrine systems. Regularly monitor glassware, bench tops, instruments, and tools with wipe tests (wipe with filter paper and measure amount of TCDD). **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 situations where TCDD contamination is low (e.g., exposure to dust contaminated with low levels of TCDD), wear an air-purifying respirator until the extent and characterization of the exposure can be determined. For materials highly contaminated with TCDD, wear respirators that consist of self-contained breathing apparatus with a full facepiece operated in a pressure-demand or other positive pressure mode. An alternate method utilizes a combination Type C supplied-air respirator, with full facepiece, operated in a pressure-demand mode and equipped with auxiliary positive pressure self-contained air supply. 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:** Consider disposable clothing due to the uncertainty of adequate decontamination. Wear protective clothing consisting of both outer (zippered coverall with attached hood and draw string or elastic sleeves, gloves and closure boots) and inner (cotton overalls, undershirts, undershorts, gloves, and socks) garments. For dust or particulate exposure, wear coveralls of a non-woven fabric such as Tyvek or spun bonded polyethylene. For exposure to liquids, wear coveralls, gloves, and boots made of chemically resistant materials such as Saranax coated Tyvek or butyl, nitrile, or neoprene rubber. 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:** Shower and change clothes after potential exposures or at the end of the work day. Separate contaminated work clothes from street clothes. Launder before reuse. Place disposable clothing in marked and approved containers for disposal. Remove this material from your shoes and clean personal protective equipment. To prevent cross-contact, provide segregated decontamination locations with separate, controlled, and well-marked entry/exit routes and locations. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9 - Physical and Chemical Properties

**Physical State:** Solid
**Appearance and Odor**: Colorless needles
**Water Solubility**: 19.3 ng/L
**Other Solubilities**: *o*-dichlorobenzene (1.4 g/L); chlorobenzene (0.72 g/L); benzene (0.57 g/L); chloroform (0.37 g/L); acetone (0.11 g/L); *n*-octanol (0.05 g/L); methanol (0.01 g/L); lard oil (0.04 g/L)

**Vapor Pressure**: $7.4 \times 10^{-10}$ mm Hg at 77 °F (25 °C)
**Formula Weight**: 322
**Melting Point**: 581-583 °F (305-306 °C)
**Octanol/Water Partition Coefficient:** log Kow=7.02
**Henry's Law Constant:** $1.62 \times 10^{-5}$ atm $m^3$/mole at 25 °C (estimated)

## Section 10 - Stability and Reactivity

**Stability:** TCDD is relatively stable toward heat, acids, and alkalis. It is changed chemically when exposed in isooctane or *n*-octanol to UV light. **Polymerization:** Hazardous polymerization cannot occur. **Chemical Incompatibilities:** None reported. **Conditions to Avoid:** Avoid heat and ignition sources. **Hazardous Decomposition Products:** Thermal oxidative decomposition of TCDD can produce toxic fumes of chlorine. Decomposition begins at 932 °F (500 °C) and complete decomposition occurs within 21 sec at 1472 °F (800 °C).

## Section 11- Toxicological Information

### Toxicity Data:*

**Eye Effects:**
Rabbit, eye: 2 mg caused moderate irritation.
**Acute Effects:**
Human, skin, $TD_{Lo}$: 107 µg/kg produced dermatitis and allergic reaction.
Mammal, oral, $LD_{50}$: 4200 ng/kg produced changes of the liver, kidney, ureter, bladder, and spleen.
Rat, oral, $LD_{50}$: 20 µg/kg
**Reproductive Effects:**
Monkey, oral, $TD_{Lo}$: 92 ng/kg (46 weeks prior to mating, on each day during gestation, and for 17 weeks following birth) caused effects on the newborn (behavioral; delayed effects).

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**Genetic Effects** *(continued)*:

Human cell: 100 pmol/L caused unscheduled DNA synthesis.

Human cell: 10 nmol/L caused DNA inhibition.

**Tumorigenic Effects:**

Rat, oral: 52 µg/kg/2 yr (intermittent) caused liver and thyroid tumors.

Rat, oral: 27 µg/kg/65 weeks (continuous) caused liver and kidney tumors.

**Multiple Dose:**

Rat, oral: 6500 ng/kg/13 weeks (intermittent) caused changes in liver and thymus weight and pigmented or nucleated red blood cells.

Mouse, skin: 97 µg/kg/13 weeks (intermittent) caused diffuse hepatitis (hepatocellular necrosis); changes in spleen; and death.

* See NIOSH, *RTECS* (HP3500000), for additional toxicity data.

## Section 12 - Ecological Information

**Environmental Transport:** Bioconcentration will occur in aquatic organisms. Due to TCDD's low solubility in water and lipids as well as its low partition coefficient in lipids, TCDD is not likely to accumulate in as many biological systems as DDT.

**Environmental Degradation:** When released to the atmosphere, gas-phase TCDD is degraded by reaction with hydroxyl radicals and direct photolysis (half-life = 8.3 days). Particulate-phase TCDD may be physically removed from air by wet and dry deposition. TCDD may be transported long distances through the atmosphere with surface water sediments being an ultimate environmental sink of airborne particulates. TCDD will absorb to sediment and limit the overall rate by which TCDD is removed from water. TCDD near the water's surface may experience significant photodegradation. 1.5 yr is the persistence half-life of TCDD in lakes. TCDD is generally resistant to biodegradation. Photodegradation on terrestrial surfaces may be an important transformation process. During warm conditions, volatilization from soil surfaces may be a major removal mechanism. Volatilization of TCDD from dry soil surfaces is likely to be faster than from wet soil surfaces. TCDD that has been mixed into soil depths beneath the upper surface boundary will volatilize extremely slowly. On soil surfaces, persistence half-life of TCDD on soil surfaces varies from less than 1 yr to 3 yr. Half-lives in soil interiors may be as long as 12 yr.

**Soil Absorption/Mobility:** TCDD is immobile in soil and is not expected to leach. Lateral movement due to surface erosion may occur.

## 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:** 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:** —

* If it is in a quantity, in one package which equals or exceeds the RQ of 1 lb (0.454 kg).

## Section 15 - Regulatory Information

**EPA Regulations:** RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) specific per 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, 132, 136, 139, 184, 187, 189, 190, 193

**Prepared By** MJ Wurth, BS **Industrial Hygiene Review** PA Roy, MPH, CIH **Medical Review** T Thoburn, MD, MPH

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## Section 1. Material Identification



**Automotive Gasoline, Lead-free, Description:** A mixture of volatile hydrocarbons composed mainly of branched-chain paraffins, cycloparaffins, olefins, naphthenes, and aromatics. In general, gasoline is produced from petroleum, shale oil, Athabasca tar sands, and coal. Motor gasolines are made chiefly by cracking processes, which convert heavier petroleum fractions into more volatile fractions by thermal or catalytic decomposition. Widely used as fuel in internal combustion engines of the spark-ignited, reciprocating type. Automotive gasoline has an octane number of approximately 90. A high content of aromatic hydrocarbons and a consequent high toxicity are also associated with a high octane rating. Some gasolines sold in the US contain a minor proportion of tetraethyllead, which is added in concentrations not exceeding 3 ml per gallon to prevent engine "knock." However, methyl-tert-butyl ether (MTBE) has almost completely replaced tetraethyllead.

**Other Designations:** CAS No. 8006-61-9, benzin, gasoline, gasolene, motor spirits, natural gasoline, petrol.

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

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† Sec. 8

**Cautions:** Inhalation of automotive gasoline vapors can cause intense burning in throat and lungs, central nervous system (CNS) depression, and possible fatal pulmonary edema. Gasoline is a dangerous fire and explosion hazard when exposed to heat and flames.

## Section 2. Ingredients and Occupational Exposure Limits

Automotive gasoline, lead-free*

**1990 OSHA PELs**
8-hr TWA: 300 ppm, 900 mg/m³
15-min STEL: 500 ppm, 1500 mg/m³

**1990-91 ACGIH TLVs**
TWA: 300 ppm, 890 mg/m³
STEL: 500 ppm, 1480 mg/m³

**1990 NIOSH REL**
None established

**1985-86 Toxicity Data***
Man, inhalation, $TC_{Lo}$: 900 ppm/1 hr; toxic effects include sense organs and special senses (conjunctiva irritation), behavioral (hallucinations, distorted perceptions), lungs, thorax, or respiration (cough)
Human, eye: 140 ppm/8 hr; toxic effects include mild irritation
Rat, inhalation, $LC_{50}$: 300 g/m³/5 min

* A typical modern gasoline composition is 80% paraffins, 14% aromatics, and 6% olefins. The mean benzene content is approximately 1%. Other additives include sulfur, phosphorus, and MTBE.
† See NIOSH, *RTECS* (LX3300000), for additional toxicity data.

## Section 3. Physical Data

**Boiling Point:** Initially, 102 °F (39 °C); after 10% distilled, 140 °F (60 °C); after 50% distilled, 230 °F (110 °C); after 90% distilled, 338 °F (170 °C); final boiling point, 399 °F (204 °C)
**Vapor Density (air = 1):** 3.0 to 4.0
**Density/Specific Gravity:** 0.72 to 0.76 at 60 °F (15.6 °C)
**Water Solubility:** Insoluble

**Appearance and Odor:** A clear (gasoline may be colored with dye), mobile liquid with a characteristic odor recognizable at about 10 ppm in air.

## Section 4. Fire and Explosion Data

| Flash Point: -45 °F (-43 °C) | Autoignition Temperature: 536 to 853 °F (280 to 456 °C) | LEL: 1.3% v/v | UEL: 6.0% v/v |
|---|---|---|---|

**Extinguishing Media:** Use dry chemical, carbon dioxide, or alcohol foam as extinguishing media. Use of water may be ineffective to extinguish fire, but use water spray to knock down vapors and to cool fire-exposed drums and tanks to prevent pressure rupture. Do not use a solid stream of water since it may spread the fuel.

**Unusual Fire or Explosion Hazards:** Automobile gasoline is an OSHA Class IB flammable liquid and a dangerous fire and explosion hazard when exposed to heat and flames. Vapors can flow to an ignition source and flash back. Automobile gasoline can also react violently with oxidizing agents.

**Special Fire-fighting Procedures:** Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode, and full protective clothing. When the fire is extinguished, use nonsparking tools for cleanup. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

## Section 5. Reactivity Data

**Stability/Polymerization:** Automotive gasoline is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

**Chemical Incompatibilities:** Automotive gasoline can react with oxidizing materials such as peroxides, nitric acid, and perchlorates.

**Conditions to Avoid:** Avoid heat and ignition sources.

**Hazardous Products of Decomposition:** Thermal oxidative decomposition of automotive gasoline can produce oxides of carbon and partially oxidized hydrocarbons.

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## Section 6. Health Hazard Data

**Carcinogenicity:** In 1990 reports, the IARC list gasoline as a possible human carcinogen (Group 2B). Although the IARC has assigned an overall evaluation to gasoline, it has not assigned an overall evaluation to specific substances within this group (inadequate human evidence).
**Summary of Risks:** Gasoline vapors are considered moderately poisonous. Vapor inhalation can cause central nervous system (CNS) depression and mucous membrane and respiratory tract irritation. Brief inhalations of high concentrations can cause a fatal pulmonary edema. Reported responses to gasoline vapor concentrations are: 160 to 270 ppm causes eye and throat irritation in several hours; 500 to 900 ppm causes eye, nose and throat irritation, and dizziness in 1 hr; and 2000 ppm produces mild anesthesia in 30 min. Higher concentrations are intoxicating in 4 to 10 minutes. If large areas of skin are exposed to gasoline, toxic amounts may be absorbed. Repeated or prolonged skin exposure causes dermatitis. Certain individuals may develop hypersensitivity. Ingestion can cause CNS depression. Pulmonary aspiration after ingestion can cause severe pneumonitis. In adults, ingestion of 20 to 50 g gasoline may produce severe symptoms of poisoning.
**Medical Conditions Aggravated by Long-Term Exposure:** None reported.
**Target Organs:** Skin, eye, respiratory and central nervous systems.
**Primary Entry Routes:** Inhalation, ingestion, skin contact.
**Acute Effects:** Acute inhalation produces intense nose, throat, and lung irritation; headaches; blurred vision; conjunctivitis; flushing of the face; mental confusion; staggering gait; slurred speech; and unconsciousness, sometimes with convulsions. Ingestion causes inebriation (drunkenness), vomiting, dizziness, fever, drowsiness, confusion, and cyanosis (a blue to dark purplish coloration of skin and mucous membrane caused by lack of oxygen). Aspiration causes choking, cough, shortness of breath, increased rate of respiration, excessively rapid heartbeat, fever, bronchitis, and pneumonitis. Other symptoms following acute exposure include acute hemorrhage of the pancreas, fatty degeneration of the liver and kidneys, and passive congestion of spleen.
**Chronic Effects:** Chronic inhalation results in appetite loss, nausea, weight loss, insomnia, and unusual sensitivity (hyperesthesia) of the distal extremities followed by motor weakness, muscular degeneration, and diminished tendon reflexes and coordination. Repeated skin exposure can cause blistering, drying, and lesions.
**FIRST AID**
**Eyes:** Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
**Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
**Inhalation:** Remove exposed person to fresh air and support breathing as needed.
**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* due to aspiration hazard. Give conscious victim a mixture of 2 tablespoons of activated charcoal mixed in 8 oz of water to drink. Consult a physician immediately.
**After first aid, get appropriate in-plant, paramedic, or community medical support.**

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** Notify safety personnel, evacuate all unnecessary personnel, remove heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and liquid contact. Use nonsparking tools. Take up small spills with sand or other noncombustible adsorbent. Dike storage areas to control leaks and spills. Follow applicable OSHA regulations (29 CFR 1910.120).
**Aquatic Toxicity:** Bluegill, freshwater, $LC_{50}$, 8 ppm/96 hr.
**Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
**EPA Designations**
RCRA Hazardous Waste (40 CFR 261.21): Characteristic of ignitability
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
**OSHA Designations**
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

## Section 8. Special Protection Data

**Goggles:** Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
**Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. There are no specific NIOSH recommendations. However, for vapor concentrations not immediately dangerous to life or health, use chemical cartridge respirator equipped with organic vapor cartridge(s), or a supplied-air 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. Materials such as neoprene or polyvinyl alcohol provide excellent/good resistance for protective clothing. **Note:** Resistance of specific materials can vary from product to product.
**Ventilation:** *Provide general and local explosion-proof exhaust 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:** 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 heat and ignition sources and strong oxidizing agents. Protect containers from physical damage. Avoid direct sunlight. Storage must meet requirements of OSHA Class IB liquid. Outside or detached storage preferred.
**Engineering Controls:** Avoid vapor inhalation and skin or eye contact. Consider a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Indoor use of this material requires explosion-proof exhaust ventilation to remove vapors. Only use gasoline as a fuel source due to its volatility and flammable/explosive nature. Practice good personal hygiene and housekeeping procedures. Wear clean work clothing daily.

**Transportation Data (49 CFR 172.101, .102)**

**DOT Shipping Name:** Gasoline (*including casing-head and natural*)
**DOT Hazard Class:** Flammable liquid
**ID No.:** UN1203
**DOT Label:** Flammable liquid
**DOT Packaging Exceptions:** 173.118
**DOT Packaging Requirements:** 173.119

**IMO Shipping Name:** Gasoline
**IMO Hazard Class:** 3.1
**ID No.:** UN1203
**IMO Label:** Flammable liquid
**IMDG Packaging Group:** II

***MSDS Collection References:*** *26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 140, 143, 146, 153, 159*
**Prepared by:** M Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** JR Stuart, MS



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Sheet No. 713
Lead (Inorganic)

Issued: 8/90

## Section 1. Material Identification



**Lead (Inorganic) (Pb) Description:** Exists widely throughout the world in a number of ores. Its main commercial source is galena (lead sulphide). Lead mineral is separated from crude ores by blast-furnace smelting, drossing, or electrolytic refining. Lead is used mostly in manufacturing storage batteries. Other uses are in manufacturing tetraethyllead and both organic and inorganic lead compounds in ceramics, plastics, and electronic devices; in producing ammunition, solder, cable covering, sheet lead, and other metal products (brass, pipes, caulking); in metallurgy; in weights and as ballast; as a chemical intermediate for lead alkyls and pigments; as a constuction material for the tank linings, piping, and equipment used to handle the corrosive gases and liquids used in sulfuric acid manufacturing, petroleum refining, halogenation, sulfonation, extraction, and condensation; and for x-ray and atomic radiation protection.

**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.

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## Section 6. Health Hazard Data, *continued*

**Target Organs:** Blood, central and peripheral nervous systems, kidneys, and gastrointestinal (GI) tract.
**Primary Entry Routes:** Inhalation, ingestion.
**Acute Effects:** An acute, short-term dose of lead could cause acute encephalopathy with seizures, coma, and death. However, short-term exposures of this magnitude are rare. Reversible kidney damage can occur from acute exposure, as well as anemia.
**Chronic Effects:** Symptoms of chronic long-term overexposure include appetite loss, nausea, metallic taste in the mouth, lead line on gingival (gum) tissue, constipation, anxiety, anemia, pallor of the face and the eye grounds, excessive tiredness, weakness, insomnia, headache, nervous irritability, fine tremors, numbness, muscle and joint pain, and colic accompanied by severe abdominal pain. Paralysis of wrist and, less often, ankle extensor muscles may occur after years of increased lead absorption. Kidney disease may also result from chronic overexposure, but few, if any, symptoms appear until severe kidney damage has occurred. Reproductive damage is characterized by decreased sex drive, impotence, and sterility in men; and decreased fertility, abnormal menstrual cycles, and miscarriages in women. Unborn children may suffer neurologic damage or developmental problems due to excessive lead exposure in pregnant women. Lead poisoning's severest result is encephalopathy manifested by severe headache, convulsions, coma, delirium, and possibly death.
**FIRST AID**
**Eyes:** Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
**Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Consult a physician if any health complaints develop.
**Inhalation:** Remove exposed person to fresh air and support breathing as needed. Consult a physician.
**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. If large amounts of lead were ingested, induce vomiting with Ipecac syrup. Consult a physician immediately.
**After first aid, get appropriate in-plant, paramedic, or community medical support.**
**Physician's Note:** For diagnosis, obtain blood pressure, blood lead level (PbB), zinc protoporphyrin (ZPP), complete blood count for microcytic anemia and basophilic stippling, urinalysis, and blood urea nitrogen (BUN) of creatinine. Examine peripheral motor neuropathy, pallor, and gingival lead line. Use Ca-EDTA to treat poison, but *never* chelate prophylactically. Consult an occupational physician or toxicologist.

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** Notify safety personnel and evacuate all unnecessary personnel immediately. Cleanup personnel should protect against inhalation of dusts or fume and contact with skin or eyes. Avoid creating dusty conditions. Water sprays may be used in large quantities to prevent the formation of dust. Cleanup methods such as vacuuming (with an appropriate filter) or wet mopping minimizes dust dispersion. Scoop the spilled material into closed containers for disposal or reclamation. Follow applicable OSHA regulations (29 CFR 1910.120).
**Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
**EPA Designations**
Listed as a RCRA Hazardous Waste (40 CFR 261.33, Appendix II—EP Toxicity Test Procedures)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per Clean Water Act, Sec. 307(a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
**OSHA Designations**
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

## Section 8. Special Protection Data

**Goggles:** Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
**Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
**Other:** Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. Protective clothing made of man-made fibers and lacking turn-ups, pleats, or pockets retain less dust from lead.
**Ventilation:** Provide general and local ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
**Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
**Contaminated Equipment:** Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
**Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially washing hands before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9. Special Precautions and Comments

**Storage Requirements:** Store in tightly closed containers in a cool, dry, well-ventilated area away from all incompatible materials, direct sunlight, and heat and ignition sources.
**Engineering Controls:** Educate worker about lead's hazards. Follow and inform employees of the lead standard (29 CFR 1910.1025). Avoid inhalation of lead dust and fumes and ingestion of lead. Use only with appropriate personal protective gear and adequate ventilation. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Avoid creating dusty conditions. Segregate and launder contaminated clothing. Take precautions to protect laundry personnel. Practice good personal hygiene and housekeeping procedures. For a variety of reasons, the lead concentration in workroom air may not correlate with the blood lead levels in individuals.
**Other Precautions:** Provide preplacement and periodic medical examinations which emphasize blood, nervous system, gastrointestinal tract, and kidneys, including a complete blood count and urinalysis. Receive a complete history including previous surgeries and hospitalization, allergies, smoking history, alcohol consumption, proprietary drug intake, and occupational and nonoccupational lead exposure. Maintain records for medical surveillance, airborne exposure monitoring, employee complaints, and physician's written opinions for at least 40 years or duration of employment plus 20 years. Measurement of blood lead level (PbB) and zinc protoporphyrin (ZPP) are useful indicators of your body's lead absorption level. Maintain worker PbBs at or below 40 µg/100 g of whole blood. To minimize adverse reproductive health effects to parents and developing fetus, maintain the PbBs of workers intending to have children below 30 µg/100 g. Elevated PbBs increase your risk of disease, and the longer you have elevated PbBs, the greater your chance of substantial permanent damage.

**Transportation Data (49 CFR 172.102)**
**IMO Shipping Name:** Lead compounds, soluble, n.o.s.
**IMO Hazard Class:** 6.1
**ID No.:** UN2291
**IMO Label:** St. Andrews Cross (X, Stow away from foodstuffs)
**IMDG Packaging Group:** III

***MSDS Collection References:*** 26, 38, 73, 84, 85, 88, 89, 90, 100, 101, 103, 109, 124, 126, 132, 133, 134, 136, 138, 139, 142, 143
**Prepared by:** MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS



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*Material Safety Data Sheets Collection:*

**Sheet No. 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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## 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 µg/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/ft$^3$, with a minimum ignition temperature of 842 °F (450 °C). Oxygen concentrations of less than 15% prevent ignition.

## Section 5. Reactivity Data

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

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## Section 6. Health Hazard Data

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

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

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

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

**Primary Entry:** Inhalation, ingestion.

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

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

**FIRST AID**

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

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

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

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

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

## Section 7. Spill, Leak, and Disposal Procedures

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

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

**OSHA Designations**

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

**EPA Designations**

RCRA Hazardous Waste (40 CFR 261.33): Not listed

CERCLA Hazardous Substance (40 CFR 302.4): Not listed

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

Listed as a SARA Toxic Chemical (40 CFR 372.65)

## Section 8. Special Protection Data

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

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

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

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

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

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

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

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

## Section 9. Special Precautions and Comments

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

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

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

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

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



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## Section 1 - Chemical Product and Company Identification 44

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

## Section 2 - Composition / Information on Ingredients

Mercury, ca 100 %wt

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

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

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

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

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

**IDLH Level**
28 mg/m$^3$

## Section 3 - Hazards Identification

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

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

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

**HMIS**
H 4*
F 0
R 0
*Chronic effects
PPE†
†Sec. 8

### Potential Health Effects

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

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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.

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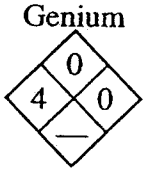


**Extinguishing Media:** Use agents suitable for surrounding fire.

**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



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

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

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

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

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

## Section 9 - Physical and Chemical Properties

**Physical State:** Liquid metal
**Appearance and Odor:** Silvery-white, odorless
**Vapor Pressure:** 0.0018 mm Hg at 77 °F (25 °C)
**Formula Weight:** 200.59
**Density ($H_2O$=1):** 13.534 g/cm$^3$ at 77 °F (25 °C)
**Boiling Point:** 674.09 °F (356.72 °C)
**Freezing Point:** -37.97 °F (-38.87 °C)
**Viscosity:** 15.5 mP at 77 °F (25 °C)
**Electrical Resistivity:** 95.76 µohm at 68 °F (20 °C)
**Water Solubility:** 0.28 µmol/L at 77 °F (25 °C)
**Other Solubilities:** Soluble in boiling sulfuric acid, nitric acid (reacts); slightly in lipids, and 2.7 mg/L in pentane. Insoluble in alcohol, ether, cold sulfuric acid, hydrogen bromide, and hydrogen iodide.
**Surface Tension:** 484 dyne/cm at 77 °F (25 °C)
**Critical Temperature:** 2664 °F (1462 °C)
**Critical Pressure:** 1587 atm

## Section 10 - Stability and Reactivity

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

**Polymerization:** Hazardous polymerization does not occur.

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

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

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

## Section 11- Toxicological Information

### Toxicity Data:*

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

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

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

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

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

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

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## Section 12 - Ecological Information

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

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

## Section 13 - Disposal Considerations

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

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

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

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

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

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

## Section 15 - Regulatory Information

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

## Section 16 - Other Information

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

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

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## Section 1. Material Identification

**Mineral Spirits, Type IV, Description:** A low dry point mineral spirit. Used as a solvent and paint thinner; in the coatings and dry cleaning industries.
**Other Designations:** CAS No. 8052-41-3; Texsolve S-2; Varsol 3; stoddard solvent; white spirits.
**Manufacturer:** Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.
**Comments:** All mineral spirits are refined petroleum distillates that Genium divides into types I, II, III, and IV (*MSDS Collection*, No. 334, 334A, 334B, and 334C, respectively). Types I and II have a standard aromatic content and 100 °F/37.78 °C and 140 °F/60 °C minimum flash points, respectively. Type III has a high aliphatic content (low or reduced aromatic content), little odor, and a 100 °F/37.78 °C minimum flash point; and type IV has a low dry point and a 100 °F/37.78 °C minimum flash point. These different types have different applications. Consult your manufacturer or supplier to ascertain the exact information applicable to your purchased mineral spirits.

R 1
I 3
S 1
K 2

Genium

HMIS
H 1
F 2
R 0
PPG*
* Sec. 8

## Section 2. Ingredients and Occupational Exposure Limits

Mineral spirits, type IV, ca 100%*

| OSHA PEL | ACGIH TLV, 1989-90 | NIOSH REL, 1987 | Toxicity Data† |
|---|---|---|---|
| TWA: 100 ppm, 525 mg/m$^3$ | TLV-TWA: 100 ppm, 525 mg/m$^3$ | 10-hr TWA: 350 mg/m$^3$<br>15-min ceiling: 1800 mg/m$^3$ | Cat, inhalation, $LC_{Lo}$: 10 g/m$^3$/2.5 hr<br>Human, eye: 470 ppm/15 min |

* All mineral spirits are mixtures that typically consist of both straight and branched hydrocarbons, paraffins, naphthenes (cycloparaffins), and aromatic hydrocarbons. However, their physical properties divide them into types I, II, III, and IV. Since these parameters vary among suppliers, the purchaser must determine the mineral spirits' composition based on the supplier's information. Note that the mineral spirits' exact composition can affect disposal, shipping, approved uses, insurance policies, and regulatory liabilities.
† See NIOSH, *RTECS* (WJ8925000), for additional irritative data.

## Section 3. Physical Data

**Boiling Point:** 300 °F/149 °C to 365 °F/185 °C*
**Specific Gravity** ($H_2O$ = 1 at 39 °F/4 °C): 0.754 to 0.800
**Molecular Weight:** Not applicable (mixture)
**Water Solubility:** Insoluble

**Appearance and Odor:** A clear, colorless liquid; a kerosene-like odor usually perceptible to humans at about 1-ppm concentration.

* This 300 °F/149 °C to 365 °F/185 °C distillation range describes a specific cut of petroleum distillates, as well as defines and distinguishes these mineral spirits from many petroleum distillates (petroleum naptha, petroleum ether, rubber solvent, kerosene, mineral seal oil, and others).

## Section 4. Fire and Explosion Data

| Flash Point: 100 °F/38.78 °C | Autoignition Temperature: >450 °F/232 °C | LEL: None reported | UEL: None reported |
|---|---|---|---|

**Extinguishing Media:** Use water fog, dry chemical, carbon dioxide ($CO_2$), or foams to put out fires involving this material. Never direct solid streams of water into burning pools of this liquid since this can scatter and spread the flames.
**Unusual Fire or Explosion Hazards:** During fires, or if heated or misted, this liquid is an explosive, flammable hazard. Finely dispersed mists are a dangerous 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. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

## Section 5. Reactivity Data

**Stability/Polymerization:** Type IV is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
**Chemical Incompatibilities:** As a hydrocarbon mixture, type IV can react dangerously with strong oxidizing agents like chlorine and oxygen, as well as with nitric, sulfuric, and phosphoric acids.
**Conditions to Avoid:** Prevent exposures to heat and ignition sources and incompatible chemicals. Perform processing operations that heat or mist type IV in a careful, controlled manner that minimizes exposure of vapors or mists to possible heat or ignition sources such as lighted tobacco products, open flames, or uninsulated heating elements.
**Hazardous Products of Decomposition:** Thermal oxidative decomposition of type IV mineral spirits can produce carbon dioxide ($CO_2$) and carbon monoxide (CO). Depending on your material's exact composition and its unreported contaminants (benzene, toluene, or other aromatics or aliphatics), degradation products could include unidentified aromatic compounds and organics. When heated to decomposition, this material may explode.

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## Section 6. Health Hazard Data

**Carcinogenicity:** Neither the NTP, IARC, nor OSHA lists mineral spirits as a carcinogen.
**Summary of Risks:** Millions of industrial workers in chemical process and allied industries have been exposed to mineral spirits with minimal serious health effects, aside from the drying, defatting (stripping away of your skin's protective fats and emolients), and irritant skin effects. However, overexposure can depress the central nervous system (CNS) with these symptoms: headache, dizziness, drowsiness, intoxication with euphoria, and possibly unconsciousness. Prolonged or repeated skin contact can cause dermatitis due to this mineral spirits' defatting effect or by sensitization.
**Medical Conditions Aggravated by Long-Term Exposure:** None reported.
**Target Organs:** Skin, eyes, nose, throat, respiratory system, and CNS.
**Primary Entry Routes:** Skin or eye contact with the liquid or inhalation of vapors.
**Acute Effects:** Irritation, redness of skin and eyes; narcotic effects like dizziness, slurred speech, or drunkeness. Ingestion may cause nausea, vomiting, diarrhea, and abdominal pain. After ingestion, the primary concern is aspiration into the lungs. Signs of aspiration pneumonitis include: fever, shortness of breath, increased rate of respiration, and rales (an abnormal rattling sound in the throat). Inhalaing this material may cause arrhythmias.
**Chronic Effects:** None reported in humans; animal testing indicates possible liver and kidney damage.
**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:** Inhalation may cause potentially lethal heart rhythm disturbances. Remove exposed person to fresh air and support breathing as needed.
**Ingestion:** Treat as an emergency. Potentially fatal aspiration hazard exists. To prevent aspiration, keep victim's head down between his knees. Never give anything by mouth to an unconscious or convulsing person. Never induce vomiting unless directed by qualified medical personnel. Even if aspiration into the lungs does not occur, ingestion of 3 to 4 oz can prove fatal in humans due to the CNS's depressed action.
**After first aid, get appropriate in-plant, paramedic, or community medical support.**
**Physician's Note:** *Aspiration of even a few milliliters of mineral spirits can be fatal!* The resulting diffused chemical irritation of the lungs can progress to fatal pulmonary edema after aspiring liquid mineral spirits. To prevent their aspiration of freshly vomited solvent, carefully monitor persons who swallow mineral spirits. Consider intubation in treating any significant ingestion.

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** *Design and practice a mineral spirits spill control and countermeasure plan (SCCP).* When a spill occurs, notify safety personnel, eliminate heat and ignition sources, provide optimum explosion-proof ventilation, and implement the SCCP. Cleanup crews must use nonsparking tools and equipment and protective clothing to prevent vapor inhalation or skin contact. Absorb the spilled material with vermiculite or a similar material and place in appropriate disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
**Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
**EPA Designations**
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
**OSHA Designations**
Listed as an Air Contaminant (29 CFR 1910.1000, Subpart Z)

## 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.
**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. Never inhale its mists or vapors, especially when processing operations heat or mist this material.

## Section 9. Special Precautions and Comments

**Storage Requirements:** Store this material in a cool, dry, well-ventilated, fireproof area away from heat and ignition sources and oxidizing agents. Protect these containers from physical damage. Store in properly labeled, closed metal drums or safety cans.
**Engineering Controls:** To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. Use only nonsparking tools and equipment.
**Comments:** Shipping regulations vary with your particular mineral spirits' physical properties (flash point, boiling point). The data below represent one of several ways to classify mineral spirits, per the actual entries in the table of regulations. Before shipping mineral spirits, ascertain how the pertinent shipping rules apply to your product.

**Transportation Data (49 CFR 172.101, .102)**

**DOT Shipping Name:** Petroleum distillate
**DOT Hazard Class:** Combustible liquid *or* Flammable liquid
**ID No.:** UN1268
**DOT Label:** None *or* Flammable liquid
**DOT Packaging Requirements:** None or 173.119
**DOT Packaging Exceptions:** 173.118a or 173.118

**IMO Shipping Name:** Petroleum distillates, n.o.s.
**IMO Hazard Class:** 3.1, 3.2, *or* 3.3
**IMO Label:** Flammable liquid
**IMDG Packaging Group:** II
**ID No.:** UN1268

***MSDS Collection* References:** 1, 6, 7, 38, 73, 84-94, 100, 103, 116, 117, 119, 120, 122, 123, 124, 126
**Prepared by:** MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD

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# Material Safety Data Sheet

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No. 84
MOLYBDENUM METAL/ POWDER
(Revision A)
Issued: March 1981
Revised: April 1988

## SECTION 1. MATERIAL IDENTIFICATION

25

**Material Name:** MOLYBDENUM METAL/POWDER

**Description (Origin/Uses):** Used to make specialty steels and nonferrous alloys; used in spark plugs and also as a lubricant additive.

**Other Designations:** Mo; NIOSH *RTECS* No. QA4680000; CAS No. 7439-98-7

**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 Molybdenum are associated with cutting, grinking, welding, etc., that produce dust, fumes, powders, and gases.

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

Not Found

## SECTION 2. INGREDIENTS AND HAZARDS

| INGREDIENTS AND HAZARDS | % | EXPOSURE LIMITS |
|---|---|---|
| Molybdenum Metal/Powder; CAS No. 7439-98-7 | Ca 100 | **OSHA PEL**<br>8-Hr TWA:* 5 mg/m³<br>8-Hr TWA:** 15 mg/m³<br><br>**ACGIH TLVs, 1987-88**<br>TLV-TWA:* 5 mg/m³<br>TLV-TWA:** 10 mg/m³<br><br>**Toxicity Data*****<br>Rat, Intraperitoneal, $LD_{Lo}$: 114 mg/kg |

*Exposure limit defined for soluble molybdenum compounds as Mo.
**Exposure limit defined for insoluble molybdenum compounds as Mo.
***See NIOSH, *RTECS*, for additional data with references to reproductive and mutagenic effects.
Note: All exposure levels are defined for dust or fume.

## SECTION 3. PHYSICAL DATA

**Boiling Point:** 10040°F (5560°C)
**Melting Point:** 4730°F (2610°C)
**Specific Gravity** ($H_2O$ = 1): 10.28 at 68°F (20°C)
**Water Solubility (%):** Insoluble
**Molecular Weight:** 96 Grams/Mole

**Appearance and Odor:** A silver white metal or dark gray/black powder; odor not found.

## SECTION 4. FIRE AND EXPLOSION DATA

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

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

**Unusual Fire or Explosion Hazards:** Molybdenum dust particles suspended in the air can explode. If a molybdenum dust cloud forms, immediately eliminate all possible sources of ignition such as sparks, open flame, etc., and spray the affected area with a water mist or fog. When powdered molybdenum is exposed to heat or sources of ignition, it is a weak fire and explosion hazard; the solid metallic form of molybdenum is less reactive. Working with this material can produce heat and sparks, which can ignite flammable materials and vapors in the workpalce.

**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

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

**Chemical Incompatibilities:** Hazardous reactions are reported for molybdenum and bromine trifluoride, chlorine trifluoride, fluorine, and lead dioxide.

**Conditions to Avoid:** Do not expose powdered molybdenum to sources of ignition; prevent dust clouds from forming.

**Hazardous Products of Decomposition:** During fires molybdenum can form oxides such as molybdenum trioxide ($MoO_3$), which is irritating to the eyes, nose, and throat.

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## SECTION 6. HEALTH HAZARD INFORMATION

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

**Summary of Risks:** Limited data suggest that molybdenum compounds have a relatively low order of toxicity. The metal itself (Mo), the ore molybdenite, and the dioxide ($MoO_2$) are less toxic than the more active and soluble molybdenum compounds such as ammonium molybdate and the trioxide ($MoO_3$). Molybdenum itself is a necessary trace element in humans that is closely associated with copper; excessive intake of molybdenum may cause a copper deficiency.

**Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** None reported.

**Primary Entry:** Skin contact, inhalation. **Acute Effects:** Mild, transient irritation of eyes, nose, and throat; elevated serum uric acid levels have been reported. **Chronic Effects:** None reported.

**FIRST AID**

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

**Skin:** 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. Give the exposed person 1 to 2 glasses of water, 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.**

## 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). Scoop up spilled molybdenum 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 and insoluble compounds as Mo)

**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:** Consult the *NIOSH Pocket Guide to Chemical Hazards* for general recommendations on respirators. 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, and aprons, etc., as required by the work environment to prevent prolonged or repeated 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 molybdenum 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 molybdenum dust.

## SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

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

**Special Handling/Storage:** Practice good housekeeping techniques to 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

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## Section 1. Material Identification



**Nickel (Ni) Description:** Found in ores in combination with sulphur, oxygen, antimony, arsenic, and/or silica. The Orford (sodium sulfide and electrolysis) and the Mond (nickel carbonyl) processes are used to refine nickel. Used in electroplating, casting operations for machine parts, manufacturing acid-resisting and magnetic alloys and tapes, synthesizing acrylic esters; in surgical and dental prostheses, coinage, catalytic gastrification of coal, paint pigments, Ni-Cd batteries, ceramics and glass; and as a catalyst in hydrogenation of fats and oils.

**Other Designations:** CAS No. 7440-02-0, Raney alloy, Raney nickel.*

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

**Cautions:** Nickel is an eye, skin, and respiratory tract irritant. *Chronic inhalation of nickel dust or fumes may cause cancer of the lungs and nasal passages. Nickel powder (Raney nickel) is a dangerous fire hazard.*

| | NFPA | Genium |
|---|---|---|
| R | 0 | |
| I | 3 | |
| S | 2 | |
| K | 1 | |
| | 4 / 2 / 0 | 1 / 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<br>Guinea pig, oral, $LD_{Lo}$: 5 mg/kg<br>Rat, implant, $TD_{Lo}$: 250 mg/kg |

* See NIOSH, *RTECS* (QR5950000), for additional mutative, reproductive, tumorigenic, and toxicity data.

## Section 3. Physical Data

**Boiling Point:** 4946 °F (2730 °C)
**Melting Point:** 2651 °F (1455 °C)
**Vapor Pressure:** 1 mm at 3290 °F (1810 °C)
**Atomic Weight:** 58.71
**Density:** 8.90 at 25 °C
**Water Solubility:** Insoluble

**Appearance and Odor:** A silvery-white, hard, malleable and ductile metal.

## Section 4. Fire and Explosion Data

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

**Extinguishing Media:** Smother with suitable dry powder or use large amounts of water.

**Unusual Fire or Explosion Hazards:** Nickel is combustible as dust or powder. Raney nickel ignites spontaneously in air. Nickel carbonyl (*MSDS Collection*, No. 226), a highly toxic substance, may form under fire conditions.

**Special Fire-fighting Procedures:** Isolate hazard area and deny entry. Since nickel dust or powder is toxic if inhaled, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

## Section 5. Reactivity Data

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

**Chemical Incompatibilities:** Nickel can react violently with fluorine, ammonium nitrate, hydrogen + dioxane, performic acid, selenium, sulfur, ammonia, hydrazine, phosphorus, and titanium + potassium chlorate. Nickel is also incompatible with oxidants. Raney nickel catalysts may initiate hazardous reactions with sulfur compounds, *p*-dioxane, hydrogen, hydrogen + oxygen, ethylene + aluminum chloride, magnesium silicate, methanol, and organic solvents + heat.

**Conditions to Avoid:** Avoid incompatibilities.

**Hazardous Products of Decomposition:** Thermal oxidative decomposition of nickel can produce highly toxic nickel carbonyl.

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## Section 6. Health Hazard Data

**Carcinogenicity:** The IARC and NTP classify nickel as, respectively, a human carcinogen (Group 1) and an anticipated human carcinogen.
**Summary of Risks:** Nickel dust or fume is a respiratory irritant that with chronic exposure may cause nasal or lung cancer in humans. The average latency period for the induction of these cancers appears to be about 25 yr (within a 4- to 51-yr range). Experimental studies show nickel also has neoplastigenic, tumorigenic, and teratogenic effects in laboratory animals. Hypersensitivity to nickel is common and can cause conjunctivitis, allergic contact dermatitis, and asthma. The allergic contact dermatitis ("nickel-itch," a pink papular erythema with pustulation and ulceration) usually clears within one week, but sensitization is permanent.
**Medical Conditions Aggravated by Long-Term Exposure:** Chronic pulmonary, upper respiratory tract, and skin disorders. Carcinoma of the paranasal sinuses, larynx, and lung may also develop.
**Target Organs:** Nasal cavities, lungs, skin.
**Primary Entry Routes:** Inhalation, dermal contact, and ingestion.
**Acute Effects:** Exposure to nickel fumes can cause upper respiratory tract irritation (with nonproductive cough, rapid breathing, dyspnea, chest tightness), metal fume fever (chills, fever, flu-like symptoms), asthma, inflammation of the lungs (noninfectious pneumonia), eye (conjunctiva) irritation, nausea, vomiting, and abdominal pain. Dermal contact causes "nickel itch." Ingesting large doses causes nausea, vomiting, and diarrhea.
**Chronic Effects:** Prolonged or repeated contact can cause nickel sensitization. Symptoms of sensitization include nickel dermatitis with eczematous skin and lichenification (hardened and leathery skin). Chronic inhalation exposure can cause chronic pulmonary irritation, chronic thickening of the mucous membranes of the nose, nasal sinusitis, anosmia (loss or impairment of the sense of smell), and perforation of the nasal septum. Chronic exposure to dust and fumes may cause carcinoma of paranasal sinuses, larynx, and lung.
**FIRST AID**
**Eyes:** Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
**Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
**Inhalation:** Remove exposed person to fresh air and support breathing as needed.
**Ingestion:** Since oral toxicity for elemental nickel is low, inducing vomiting is seldom necessary. In cases of severe vomiting or diarrhea, treat for fluid replacement.
**After first aid, get appropriate in-plant, paramedic, or community medical support.**
**Physician's Note:** Chronic exposure to nickel dust may cause *eosinophilic pneumonitis* (Loeffler's syndrome) which responds well to systemic cortico-steroids. There are cases of host rejection of nickel-containing prostheses after development of nickel sensitivity.

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personal should protect against vapor inhalation and dermal contact. Avoid dust generation. Using nonsparking tools, carefully scoop spilled material into appropriate containers for reclamation or disposal. After completing material pickup, wash spill site. Do not release to sewers or waterways. Follow applicable OSHA regulations (29 CFR 1910.120).
**Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
**EPA Designations**
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1 lb (0.454 kg) [* per Clean Water Act, Sec. 307(a)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
**OSHA Designations**
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

## Section 8. Special Protection Data

**Goggles:** Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
**Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
**Other:** Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
**Ventilation:** Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL, ACGIH TLV, and NIOSH REL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
**Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
**Contaminated Equipment:** Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
**Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9. Special Precautions and Comments

**Storage Requirements:** Store in tightly closed containers in a cool, dry, well-ventilated area away from incompatible materials (Sec. 2). Protect against physical damage. Store Raney nickel under inert gas or water in tightly closed containers away from heat or ignition sources, acids, caustics, and oxidizing materials.
**Engineering Controls:** Minimize all possible exposures to potential carcinogens. Avoid vapor inhalation and dermal contact. Use only with appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
**Other Precautions:** Provide preplacement and periodic medical examinations that emphasize the skin, nasal cavities, and lungs, including a 14" x 17" chest roentgenogram and urine nickel determinations.

**Transportation Data (49 CFR 172.102)**
**IMO Shipping Name:** Nickel catalyst, wetted with not less than 40% water or other suitable liquid, by weight, finely divided, activated, or spent
**IMO Hazard Class:** 4.2
**ID No.:** UN1378
**IMO Label:** Spontaneously combustible
**IMDG Packaging Group:** II

*MSDS Collection* **References:** 26, 38, 73, 84, 85, 88, 89, 90, 100, 101, 103, 109, 124, 126, 132, 133, 134, 136, 138, 139, 140, 142, 143
**Prepared by:** MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD; **Edited by:** JR Stuart, MS



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## 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.

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**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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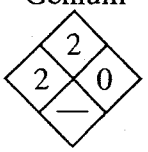


**Flash Point**: DDT itself is noncombustible but is dissolved in a variety of solvents. The average quoted Flash Point is 162 °F (72.2 °C) although the specific vehicle is not identified.

**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.



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**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.

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**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

**Prepared By** ..... M Gannon, BA
**Industrial Hygiene Review** ..... PA Roy, MPH, CIH
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## Section 1 - Chemical Product and Company Identification 44

**Product/Chemical Name:** Malathion
**Chemical Formula:** $(CH_3O)_2P(S)SCH(COOC_2H_5)CH_2COOC_2H_5$
**CAS No.:** 121-75-5
**Synonyms:** carbophos; Cythion; O,O-dimethyl dithiophosphate of diethyl mercaptosuccinate; O,O-dimethyl-S-(1,2-dicarbethoxyethyl) phosphorodithioate; Maldison; mercaptothion
**Derivation:** Obtained from diethyl maleate and dimethyldithiophosphoric acid. **General Use:** As an insecticide for the control of mosquitoes, flies, spiders, animal ectoparasites, and human head and body lice. **Vendors:** Consult the latest *Chemical Week Buyers' Guide.* (73)

## Section 2 - Composition / Information on Ingredients

Malathion, 99.6 % vol: technical grade; 25% and 50%: wettable powders
Trace Impurities: phosphorothioate and phosphorodithioate; malaoxon (crude grade impurity)

**OSHA PELs, *Skin***
8-hr TWA :15 mg/m$^3$, total dust

Vacated 1989 Final Rule Limit:
8-hr TWA: 10 mg/m$^3$, total dust
5 mg/m$^3$, respirable fraction

**NIOSH REL, *Skin***
10-hr TWA: 10 mg/m$^3$

**IDLH Level**
5000 mg/m$^3$

**DFG (Germany) MAK**
Ceiling: 15 mg/m$^3$, total dust

**ACGIH TLVs, *Skin***
TWA: 10 mg/m$^3$*

* Biological Exposure Index for organophosphorus cholinesterase inhibitors: 70% of individual's baseline.

## Section 3 - Hazards Identification

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Malathion is a colorless (when pure) to light-amber liquid with a skunk-like or garlic odor. It is an anticholinesterase agent and severe intoxication causes profound pulmonary secretions and respiratory distress. Take the necessary precautions to prevent any exposure to malathion. It is absorbed through the skin and may produce systemic effects.

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

**HMIS**
H 2
F 1
R 1

**PPE†**
†Sec. 8

### Potential Health Effects

**Primary Entry Routes:** Inhalation, ingestion, skin absorption.
**Target Organs:** Respiratory system, liver, blood cholinesterase, gastrointestinal tract, and central nervous and cardiovascular systems.
**Acute Effects**
**Severe Intoxication by all Routes:** Weakness, general twitching and paralysis, dizziness, confusion, staggering, slurred speech, sweating, irregular or slow heartbeat, convulsions, breathing may stop, and coma. **Inhalation:** Tightness of the chest, wheezing, increased pulmonary secretions, bluish discoloration of skin, small pupils, aching in and behind eyes, blurred vision, tearing, runny nose, headache, and watering of the mouth. **Eye:** Irritation.
**Skin:** Skin absorption causes sweating and twitching in area of absorption usually within 15 min to 4 hr. Weak skin sensitization and dermatitis may occur at high exposures.
**Ingestion:** Loss of appetite, nausea, vomiting, abdominal cramps, diarrhea within 2 hr.
**Carcinogenicity:** IARC, NTP, and OSHA do not list malathion as a carcinogen. IARC designates malathion as Group 3 (not classifiable as to carcinogenicity to humans).
**Medical Conditions Aggravated by Long-Term Exposure:** Central nervous system disorders.
**Chronic Effects:** Repeated exposure to malathion may make a person more susceptible to the effects of organophosphates.
**Comments:** Malathion is an anticholinesterase agent which causes the inactivation of the enzyme cholinesterase resulting in the accumulation of acetylcholine at synapses in the neuromuscular system and secretory glands. It is less toxic to humans than most anticholinesterase agents because malathion and its metabolite, malaoxon, are metabolized in the liver to an inactive form. The acute lethal dose is estimated to be somewhat below 1.0 g/kg.

## 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.

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**Skin Contact:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Thoroughly wash exposed area with soap and water. Do repeat soap washings. 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 possible early onset of respiratory depression and seizures. Consider gastric lavage after control of any seizures.

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

**Note to Physicians:** Give 5 mg of atropine intravenously. Atropine may induce ventricular fibrillation in the presence of cyanosis. Repeat the dose of atropine at 5- to 10-minute intervals until signs of atropinization appear (dry, flushed skin, tachycardia as high as 140 beats/min, and pupillary dilatation). Repeat the dose of atropine if muscarinic symptoms appear. Maintain a mild degree of atropinization for at least 48 hr. Pralidoxime (2-PAM, Protopam) chloride is a cholinesterase reactivator that complements the action of atropine. For moderate-to-severe cases, give adults 1 to 2 g intravenously at a rate not in excess of 500 mg/min. A second dose of 1 g is indicated if muscle weakness has not been relieved, or if it recurs within 20 min. Pralidoxime chloride is ineffective after aging has occurred. Morphine, aminophyline, and phenothiazines are contraindicated. Depression in red blood cell cholinesterase in excess of 50% activity is generally associated with severe symptoms. Correlation between cholinesterase levels and clinical effects in milder poisonings may be poor. Individuals homozygous for the CHE gene display a defective serum butyrylcholinesterase and are particularly vulnerable to poisoning by organophosphorus insecticides.

**Special Precautions/Procedures:** Emergency personnel should protect against exposure when rescuing victims.

## Section 5 - Fire-Fighting Measures

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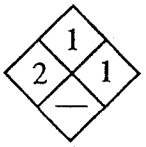


**Flash Point**: >325 °F (>163 °C)
**Flash Point Method:** OC
**Autoignition Temperature**: None reported.
**LEL**: None reported.
**UEL**: None reported.
**Flammability Classification:** Class IIIB Combustible Liquid, but may be difficult to ignite.
**Extinguishing Media:** Small fires: use dry chemical or carbon dioxide. Large fires: use water spray or foam.
**Unusual Fire or Explosion Hazards:** Containers may explode in the heat of fire.
**Hazardous Combustion Products:** Sulfur dioxide, phosphoric acid, phosphorus oxides, and carbon monoxide.
**Fire-Fighting Instructions:** If feasible and without undue risk, move containers from fire hazard area. Otherwise, cool fire-exposed containers with water spray until well after fire is extinguished. 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. Wear chemically protective clothing specifically recommended by the manufacturer. Decontaminate equipment and clothing with a chlorine bleach solution.

## Section 6 - Accidental Release Measures

**Spill /Leak Procedures:** Notify safety personnel of large spills, evacuate all unnecessary personnel, provide adequate ventilation, and remove all heat and ignition sources. Cleanup personnel should protect against exposure. Fully-encapsulating, vapor-protective clothing (polycarbonate, butyl rubber, PVC, nitrile, Neoprene) is recommended.

**Small Spills:** Take up with sand or noncombustible absorbent material and place into containers for later disposal. For dry spills, scoop up with a clean shovel and place into a clean, dry container for disposal.

**Large Spills**

**Containment:** For large spills, dike far ahead of liquid spill for later disposal. Do not release into sewers or waterways.
**Cleanup:** Decontaminate equipment and surfaces with an alkaline solution (5% sodium hydroxide).
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Avoid any contact with skin or vapor inhalation. Use only with adequate personal protective equipment and proper ventilation.

**Storage Requirements:** Store in tightly closed and properly labeled containers in a cool, well-ventilated area. Outdoor or detached storage is preferred. *Do not* store in iron, steel, tin plate, lead, or copper containers.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas.

**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:** Provide preplacement and periodic medical exam with emphasis on the respiratory system, liver, and blood cholinesterase levels. Biological Exposure Index (BEI): cholinesterase activity in red blood cells (timing is discretionary) is 70% of individual's baseline. Background levels are included in the BEI value. Consider precluding from exposure those


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individuals whose red blood cell cholinesterase falls to or below 40% of the preexposure baseline until the activity returns to within 70% of the preexposure baseline. **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 concentrations ≤ 100 mg/m$^3$, wear any supplied-air respirator, any SCBA, or any chemical cartridge respirator with organic vapor cartridge(s) in combination with a dust, mist, and fume filter. For concentrations ≤ 250 mg/m$^3$, wear any supplied-air respirator operated in a continuous-flow mode; or any powered, air-purifying respirator with organic vapor cartridge(s) in combination with a dust, mist, and fume filter. For concentrations ≤ 500 mg/m$^3$, wear any self-contained breathing apparatus with a full facepiece or any supplied-air respirator with a full facepiece or any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s) in combination with a high-efficiency particulate filter; or any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having a high-efficiency particulate filter; or any powered, air-purifying respirator with a tight-fitting facepiece and organic vapor cartridge(s) in combination with a high-efficiency particulate filter; or any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode. For concentrations ≤ 5000 mg/m$^3$, wear any supplied-air respirator 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. **Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Whole-body coveralls and chemically protective footwear are recommended. Wear protective eyeglasses or chemical safety, splash-proof goggles and face shields (8 inch minimum) 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
**Appearance and Odor**: Colorless (when pure) to light amber with a skunk-like or garlic odor
**Odor Threshold**: 13.5 mg/m$^3$
**Vapor Pressure**: 1.25 x 10$^{-4}$ mm Hg at 68 °F (20 °C); 4 x 10$^{-5}$ at 86° F (30 °C)
**Formula Weight**: 330.36
**Density ($H_2O$=1, at 4 °C)**: 1.23 at 77 °F (25 °C)
**Water Solubility**: Slightly soluble; 145 ppm at 20 °C
**Other Solubilities**: Alcohols, esters, ketones, ethers, vegetable oils, benzene, hexane, aromatic and alkylated aromatic hydrocarbons; limited solubility in paraffin hydrocarbons
**Boiling Point**: 140 °F (60 °C); decomposes
**Freezing/Melting Point**: 37.2 °F (2.9 °C)
**Refraction Index:** 1.4960 at 20 °C/D
**Surface Tension:** 37.1 dynes/cm at 75 °F (24 °C)
**Octanol/Water Partition Coefficient:** Log Kow=2.36

## Section 10 - Stability and Reactivity

**Stability:** Malathion is stable in an aqueous solution buffered to pH 5.26. **Polymerization:** Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Corrodes iron, steel, tin plate, lead and copper; will attack some forms of plastics, rubber, and coatings; and is also incompatible with strong oxidizers, magnesium, and alkaline pesticides. **Conditions to Avoid:** Avoid heat and ignition sources and incompatibles. **Hazardous Decomposition Products:** Thermal oxidative decomposition of malathion can produce sulfur dioxide, phosphoric acid, carbon monoxide, and phosphorus oxides. Malathion may isomerise at high temperatures and form the more toxic isomalathion. It starts to decompose at 140 °F (60 °C) and at > 212 °F (> 100 °C) it decomposes explosively.

## Section 11- Toxicological Information

### Toxicity Data:*

**Acute Inhalation Effects:**
Rat, inhalation, $LC_{50}$: 84600 µg/m$^3$/4 hr
**Acute Effects:**
Woman, oral, $LD_{Lo}$: 246 mg/kg caused blood pressure lowering not characteristic in autonomic section, chronic pulmonary edema, and dermatitis.
Man, oral, $LD_{Lo}$: 471 mg/kg caused coma, blood pressure lowering not characteristic in autonomic section, and shortness of breath.
Rat, oral, $LD_{50}$: 290 mg/kg
Rat, skin, $LD_{50}$: > 4444 mg/kg

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**Reproductive Effects:**
Rat, oral, 283 mg/kg administered to the female during 9 days of pregnancy caused specific developmental abnormalities of the urogenital system.

**Genetic Effects:**
Human, lymphocyte: 70 mg/L caused DNA inhibition.
Human, fibroblast: 5 mg/L caused sister chromatid exchange.

* See NIOSH, *RTECS* (WM8400000), for additional toxicity data.

## Section 12 - Ecological Information

**Ecotoxicity:** Bluegill, fresh water, TLm, 96 hr: 0.09 ppm; Marine crustaceae, 96 hr: 0.033-0.083 ppm. Waterfowl, $LD_{50}$: 1485 mg/kg. **Environmental Fate:** A Koc of 280 has been estimated on the reported solubility of 145 ppm at 20 °C, vapor pressure of $4 \times 10^{-5}$ mm Hg at 30 °C, and a Henry's law constant of $1.2 \times 10^{-7}$ atm $m^3$/mol. **Environmental Degradation:** If released to water, malathion is subject to biodegradation and photodegradation at the surface and it may moderately absorb to sediment, but will not be expected to bioconcentrate in aquatic organisms. Volatilization from water should not be an important fate process. Hydrolysis in water may be an important fate process based on reported half-life range of 0.2 weeks at pH 8.0 to 21 weeks at pH 6.0. Products of hydrolysis include malaoxon; malathion, alpha and beta monoacid; O,O-dimethyl phosphorodithionic acid; diethyl fumarate; diethyl thiomalate; and O,O-dimethyl phosphorothionic acid. Iron catalyzes hydrolysis and humic substances accelerate photolysis. Persistence of malathion in water from 4 rivers ranged from 52% still present after 11 days to 21% after 14 days. Biodegradation may be an important fate process, especially in soils at pH <7 where the rate of hydrolysis may be slow relative to the rate of biodegradation. The major metabolite in soil is malathion beta monoacid. **Soil Absorption/Mobility:** Malathion will moderately bind to the soil and it will be subject to significant biodegradation and hydrolysis. Leaching is a viable route of transport in soil. Absorption is the best in high organic content, enhanced by the presence of metallic clays. The half-life in soil: 4 to average 6 days. **Analytical Method:** EPA Method 8141 is a gas chromatographic method used to determine malathion in ground water, soil, and non-water miscible waste.

## Section 13 - Disposal Considerations

**Disposal:** Incinerate with flammable solvent in a furnace equipped with an afterburner and scrubber (permit-approved facility). Wastewater treatment technology: biological treatment and reverse osmosis. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations. **Container Cleaning and Disposal:** Triple rinse containers and dispose of waste water as you would dispose of malathion unless it can be used for diluent.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name**: Organophosphorus pesticides, liquid, toxic, n.o.s.
**Shipping Symbols:**
**Hazard Class**: 6.1
**ID No.**: UN3018
**Packing Group**: I
**Label**: POISON
**Special Provisions (172.102)**: N76, T42

**Packaging Authorizations**
**a) Exceptions**: None
**b) Non-bulk Packaging**: 173.201
**c) Bulk Packaging**: 173.243

**Quantity Limitations**
**a) Passenger, Aircraft, or Railcar:** 1 L
**b) Cargo Aircraft Only**: 30 L

**Vessel Stowage Requirements**
**a) Vessel Stowage**: B
**b) Other**: 40

## Section 15 - Regulatory Information

**EPA Regulations:**
RCRA Hazardous Waste (40 CFR 261.33): Not listed*
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per CWA, Sec. 311 (b)(4)
CERCLA Reportable Quantity (RQ), 100 lb (45.4 kg)
SARA Toxic Chemical (40 CFR 372.65): Not listed
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
**OSHA Regulations:**
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)
* Malathion may be classified as a RCRA Hazardous Waste, Characteristic of Corrosivity, because it corrodes steel. See 40 CFR 261.22 for specific criteria.

## Section 16 - Other Information

**References:** 26, 73, 100, 101, 103, 124, 132, 136, 139, 140, 148, 153, 164, 167, 168, 174, 175, 176, 180, 183, 189, 190
**Prepared By** MJ Wurth, BS **Industrial Hygiene Review** RE Langford, PhD, CIH **Medical Review** J Brent, MD, PhD
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**Sheet No. 683**
**Polychlorinated Biphenyls (PCBs)**

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



## Section 1. Material Identification

**Polychlorinated Biphenyls [$C_{12}H_{10-n}Cl_n$ (n=3, 4, 5)] Description:** A class of nonpolar chlorinated hydrocarbons with a biphenyl nucleus (two benzene nuclei connected by a single C-C bond) in which any or all of the hydrogen atoms have been replaced by chlorine. Commercial PCBs are mixtures of chlorinated biphenyl isomers with varying degrees of chlorination. Prepared industrially by the chlorination of biphenyl with anhydrous chlorine in the presence of a catalyst such as ferric chloride or iron filings. Except for limited research and development applications, PCBs have not been produced in the US since 1977. When large quantities of PCBs were manufactured in the US, they were marketed under the tradename Aroclor (Monsanto) and were characterized by four digit numbers. The first two digits indicating biphenyls (12), triphenyls (54), or both (25, 44); the last two digits indicating the weight percent of chlorine. PCBs' thermal stability, nonflammability, and high dielectric capability made them very useful in electrical equipment. Formerly used as additives in hydraulic fluids, heat transfer systems, lubricants, cutting oils, printer's ink, fire retardants, asphalt, brake linings, automobile body sealants, plasticizers, adhesives, synthetic rubber, floor tile, wax extenders, dedusting agents, pesticide extenders, and carbonless reproducing paper. PCBs are still used in certain existing electrical capacitors and transformers that require enhanced electrical protection to avoid heating from sustained electric faults.

**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

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.

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## Section 6. Health Hazard Data

**Carcinogenicity:** The IARC,[164] and NTP[169] list PCBs as an IARC probable carcinogen (overall evaluation is 2A; limited human data; sufficient animal data) and NTP anticipated carcinogen, respectively. **Summary of Risks:** PCBs are potent liver toxins that can be absorbed through unbroken skin in toxic amounts without immediate pain or irritation. PCBs have low acute toxicity, but can accumulate in fatty tissue and severe health effects may develop later. Generally, toxicity increases with a higher chlorine content; PCB-oxides are more toxic. The toxic action on the liver also increases with simultaneous exposure to other liver toxins, e.g. chlorinated solvents, alcohol, and certain drugs. Pathological pregnancies (abnormal pigmentations, abortions, stillbirths, and underweight births) have been associated with increased PCB serum levels in mothers; PCBs can be passed in breast milk. PCBs can affect the reproductive system of adults. **Medical Conditions Aggravated by Long-Term Exposure:** Skin, liver, and respiratory disease. **Target Organs:** Skin, liver, eyes, mucous membranes, and respiratory tract. **Primary Entry Routes:** Inhalation, dermal contact, ingestion. **Acute Effects:** Exposure to PCB vapor or mist is severely irritating to the skin, eyes, nose, throat, and upper respiratory tract. Intense acute exposure to high concentrations may result in eye, lung, and liver injury. Systemic effects include nausea, vomiting, increased blood pressure, fatigue, weight loss, jaundice, edema and abdominal pain. Cognitive, neurobehavior and psychomotor impairment and memory loss have also been seen after acute exposure. **Chronic Effects:** Repeated exposure to PCBs can cause chloroacne; redness, swelling, dryness, thickening and darkening of the skin and nails; swelling and burning of the eyes, and excessive eye discharge; distinctive hair follicles; gastrointestinal disturbances; neurological symptoms including headache, dizziness, depression, nervousness, numbness of the extremities, and joint and muscle pain; liver enlargement; menstrual changes in women; and chronic bronchitis. Cancer, primarily liver, is also a possible result of exposure, but data is inconclusive.

**FIRST AID** **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Rinsing eyes with medical oil (olive, mineral) initially may remove PCB and halt irritation better than water rinsing alone. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. *Multiple soap and water washings are necessary.* Avoid the use of organic solvents to clean the skin. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** In most cases, accidental PCB ingestion will not be recognized until long after vomiting would be of any value. Never give anything by mouth to an unconscious or convulsing person. Vomiting of the pure substance may cause aspiration. Consult a physician. **Note to Physicians:** Monitor patients for increased hepatic enzymes, chloroacne, and eye, gastrointestinal, and neurologic symptoms listed above. Diagnostic tests include blood levels of PCBs and altered liver enzymes.

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** Notify safety personnel, evacuate all unnecessary personnel, provide adequate ventilation, and isolate hazard area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. For small spills, take up with sand or other noncombustible material and place into containers for later disposal. For larger spills, dike far ahead of spill to contain for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** PCBs have been shown to bio-concentrate significantly in aquatic organisms. **Ecotoxicity:** Bluegill, TLm: 0.278 ppm/96 hr. Mallard Duck, $LD_{50}$: 2000 ppm. **Environmental Degradation:** In general, the persistence of PCBs increases with an increase degree of chlorination. **Soil Absorption/Mobility:** PCBs are tightly absorbed in soil and generally do not leach significantly in most aqueous soil systems. However, in the presence of organic solvents, PCBs may leach rapidly through the soil. Volatilization of PCBs from soil may be slow, but over time may be significant. **Disposal:** Approved PCB disposal methods include: incineration with scrubbing, high-efficiency boilers, landfills, and EPA-approved alternative disposal methods. Each disposal method has various criteria. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

**EPA Designations**

RCRA Hazardous Waste (40 CFR 261.33): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1 lb (0.454 kg) [* per CWA, Sec. 311(b)(4) and 307(a)]

**OSHA Designations**

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

## Section 8. Special Protection Data

**Goggles:** Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. Minimum respiratory protection should include a combination dust-fume-mist and organic vapor cartridge or canister or air-supplied, depending upon the situation. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. Butyl rubber, neoprene, Teflon, and fluorocarbon rubber have break through times greater than 8 hrs. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Segregate contaminated clothing in such a manner so that there is no direct contact by laundry personnel. Implement quality assurance to ascertain the completeness of the cleaning procedures. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9. Special Precautions and Comments

**Storage Requirements:** Store in a closed, labelled, container in a ventilated area with appropriate air pollution control equipment. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Inform employees of the adverse health effects associated with PCBs. Limit access to PCB work areas to authorized personnel. Consider preplacement and periodic medical examinations with emphasis on the skin, liver, lung, and reproductive system. Monitor PCB blood levels. Consider possible effects on the fetus. Keep medical records for the entire length of employment and for the following 30 yrs.

**Transportation Data (49 CFR 172.101)**

**DOT Shipping Name:** Polychlorinated biphenyls
**DOT Hazard Class:** 9
**ID No.:** UN2315
**DOT Packing Group:** II
**DOT Label:** CLASS 9
**Special Provisions (172.102):** 9, N81

**Packaging Authorizations**
**a) Exceptions:** 173.155
**b) Non-bulk Packaging:** 173.202
**c) Bulk Packaging:** 173.241

**Quantity Limitations**
**a) Passenger Aircraft or Railcar:** 100 L
**b) Cargo Aircraft Only:** 220 L

**Vessel Stowage Requirements**
**a) Vessel Stowage:** A
**b) Other:** 34

***MSDS Collection References:*** 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 163, 164, 168, 169, 174, 175, 180

**Prepared by:** MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy MPH, CIH; **Medical Review:** AC Darlington, MD

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# Radioactive Material Safety Data Sheet

This data sheet presents information on radioisotopes only.
For information on chemical compounds incorporating this radionuclide, see the relevant Material Safety Data Sheet.

## Strontium-90

### Part 1 – Radioactive Material Identification

| | | | |
|---|---|---|---|
| **Common Names:** | Strontium-90 | **Chemical Symbol:** | Sr-90 or $^{90}Sr$ |
| **Atomic Number:** | 38 | **Mass Number:** | 90 (52 neutrons) |
| **Chemical Form:** | Strontium metal | **Physical Form:** | A strontium compound incorporated on a ceramic insert or rolled silver foil. |

### Part 2 – Radiation Characteristics

**Physical half-life:** 28.6 years **Specific Activity (GBq/g):** 5,050

| Principle Emissions | $E_{Max}$ (keV) | $E_{eff}$ (keV) | Dose Rate (mSv/h/GBq at 1 m) | Shielding Required |
|---|---|---|---|---|
| Beta* (β) | 546 (100%)<br>2,283 (99.9%)[b] | 196<br>935 | 9.65[a,c] | - |
| Gamma (γ) / X-Rays | - | - | - | - |
| Alpha (α) | - | - | - | - |
| Neutron (n) | - | - | - | - |

* Where Beta radiation is present, Bremsstrahlung radiation will be produced. Shielding may be required.
Note: Only emissions with abundance greater than 10% are shown.
[a] *The Health Physics and Radiological Health Handbook*, Scintra, Inc., Revised Edition, 1992
[b] This beta is produced by the yttrium-90 progeny, which quickly comes into equilibrium with the strontium parent.
[c] Total dose produced by strontium-90 in equilibrium with the yttrium-90 progeny.

**Progeny:** Yttrium-90 (Yt-90) {half-life: 64.4 hours; decay progeny: zirconium-90 (Zn-90)}

### Part 3 – Detection and Measurement

**Methods of detection (in order of preference)**

| |
|---|
| 1. A radiation survey meter equipped with a thin-window, energy-compensated Geiger Mueller detector. |
| 2. A radiation contamination monitor equipped with a Geiger Mueller pancake detector. |

| |
|---|
| 3. A radiation survey meter equipped with a plastic scintillator detector. |

**Dosimetry**

Whole Body ☐ Skin ☑ Extremity ☑ Neutron ☐

| | | |
|---|---|---|
| Internal: | Sealed sources pose no internal radiation hazard. However, in the event of loss of containment by the sealed source, all precautions should be taken to prevent inhalation or ingestion of the material. | |
| Critical Organ(s): | Bone tissues | |
| Annual dose limits: | *Non-nuclear energy workers:* | 1mSv per year |
| | *Nuclear energy workers:* | a) 50 mSv in one year |
| | | b) 100 mSv total over five years |
| | *Pregnant nuclear energy workers:* | 4 mSv over the balance of the pregnancy |

**Part 4 – Preventive Measures**

*Always use the principles of time, distance and shielding to minimize dose*

| | |
|---|---|
| Engineering Controls: | Sealed radioactive sources used in industrial applications should always be within a protective source housing to minimize radiation dose and to protect the source capsule from damage. |
| Personal Protective Equipment (*for normal handling of unsealed sources only. Always wear disposable gloves, safety glasses, personal protective equipment and clothing as appropriate to the material handled).* No special PPE required. | |
| Special Storage Requirements: | None |

**Part 5 – Control Levels**

| Oral Ingestion | Inhalation | |
|---|---|---|
| ALI (kBq) | ALI (kBq) | DAC (Bq/ml) |
| 1,110 | 740 | $2.96 \times 10^{-7}$ |
| Exemption Quantity (EQ): | 10,000 Bq | |

## Part 6 – Non-Radiological Hazards

None identified at this time.

*OSHA Permissible Exposure Limit (PEL)*
No limits set at this time

## Part 7 - Emergency Procedures

*The following is a guide for first responders. The following actions, including remediation, should be carried out by qualified individuals. In cases where life-threatening injury has resulted,* ***first*** *treat the injury,* ***second*** *deal with personal decontamination.*

### Personal Decontamination Techniques

- Wash well with soap and water and monitor skin
- Do not abrade skin, only blot dry
- Decontamination of clothing and surfaces are covered under operating and emergency procedures

### Spill and Leak Control

- Alert everyone in the area
- Confine the problem or emergency (includes the use of absorbent material)
- Clear area
- Summon Aid

### Damage to Sealed Radioactive Source Holder

- Evacuate the immediate vicinity around the source holder
- Place a barrier at a safe distance from the source holder (min. 5 meters)
- Identify area as a radiation hazard
- Contact emergency number posted on local warning sign

### Suggested Emergency Protective Equipment

- Gloves
- Footwear Covers
- Safety Glasses
- Outer layer or easily removed protective clothing (as situation requires)

Revision Date: December 17, 2001

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# Radioactive Material Safety Data Sheet

This data sheet presents information on radioisotopes only.
For information on chemical compounds incorporating this radionuclide, see the relevant Material Safety Data Sheet.

## Cesium-137

### Part 1 – Radioactive Material Identification

**Common Names:** Cesium-137 **Chemical Symbol:** Cs-137 or $^{137}Cs$

**Atomic Number:** 55 **Mass Number:** 137 (82 neutrons)

**Chemical Form:** Cesium chloride **Physical Form:** A pellet of cesium ceramic housed in a welded stainless steel capsule

### Part 2 – Radiation Characteristics

**Physical half-life:** 30.22 years **Specific Activity (GBq/g):** 3,220

| Principle Emissions | $^{E}$Max (keV) | $^{E}$eff (keV) | Dose Rate (µSv/h/GBq at 1m) | Shielding Required |
|---|---|---|---|---|
| Beta* (β) | 511 (94.6%) | 157 | - | - |
| Gamma (γ) / X-Rays | 662 (89.9%) | - | 103[a] | HVL Lead: 0.65 cm |
| Alpha (α) | - | - | - | - |
| Neutron (n) | - | - | - | - |

* Where Beta radiation is present, Bremsstrahlung radiation will be produced. Shielding may be required.
Note: Only emissions with abundance greater than 10% are shown.
[a] *The Health Physics and Radiological Health Handbook*, Scintra, Inc., Revised Edition, 1992

**Progeny:** Barium-137m (Ba-137m)

### Part 3 – Detection and Measurement

**Methods of detection (in order of preference)**

1. A radiation survey meter equipped with an energy-compensated Geiger Mueller detector.
2. Ion chamber survey meter – tends to be less sensitive than a Geiger Mueller survey meter but is able to respond more precisely in higher radiation fields.
3. Gamma scintillation detector – very sensitive but is also energy dependent. Must be calibrated for Cs-137 before it can be used for dose assessment surveys.

**Dosimetry**

| Whole Body ☑ | Skin ☐ | Extremity ☐ | Neutron ☐ |
|---|---|---|---|

| | | |
|---|---|---|
| Internal: | Sealed sources pose no internal radiation hazard. However, in the event of loss of containment by the sealed source, all precautions should be taken to prevent inhalation or ingestion of the material. | |
| Critical Organ(s): | None known at this time. | |
| Annual dose limits: | *Non-nuclear energy workers:* | 1mSv per year |
| | *Nuclear energy workers:* | a) 50 mSv in one year<br>b) 100 mSv total over five years |
| | *Pregnant nuclear energy workers:* | 4 mSv over the balance of the pregnancy |

**Part 4 – Preventive Measures**

*Always use the principles of time, distance and shielding to minimize dose*

| | |
|---|---|
| Engineering Controls: | Sealed radioactive sources used in industrial applications should always be within a protective source housing to minimize radiation dose and to protect the source capsule from damage. |
| Personal Protective Equipment (*for normal handling of unsealed sources only. Always wear disposable gloves, safety glasses, personal protective equipment and clothing as appropriate to the material handled).*<br>No special PPE required. | |
| Special Storage Requirements: | None |

**Part 5 – Control Levels**

| Oral Ingestion | Inhalation | |
|---|---|---|
| ALI (kBq) | ALI (kBq) | DAC (Bq/ml) |
| 3700 | 7400 | $2.2 \times 10^{-3}$ |
| Exemption Quantity (EQ): | 10,000 Bq | |

**Part 6 – Non-Radiological Hazards**

No potential health effects are known regarding non-radiological hazards associated with cesium. However, large oral doses of the material may cause gastrointestinal disturbances. Chronic effects are not known at this time.

*OSHA Permissible Exposure Limit (PEL):*

15 mg/m3 total dust, 5 mg/m3 respirable fraction for nuisance dusts

## Part 7 - Emergency Procedures

*The following is a guide for first responders. The following actions, including remediation, should be carried out by qualified individuals. In cases where life-threatening injury has resulted,* ***first*** *treat the injury,* ***second*** *deal with personal decontamination.*

**Personal Decontamination Techniques**

- Wash well with soap and water and monitor skin
- Do not abrade skin, only blot dry
- Decontamination of clothing and surfaces are covered under operating and emergency procedures

**Spill and Leak Control**

- Alert everyone in the area
- Confine the problem or emergency (includes the use of absorbent material)
- Clear area
- Summon Aid

**Damage to Sealed Radioactive Source Holder**

- Evacuate the immediate vicinity around the source holder
- Place a barrier at a safe distance from the source holder (min. 5 meters)
- Identify area as a radiation hazard
- Contact emergency number posted on local warning sign

**Suggested Emergency Protective Equipment**

- Gloves
- Footwear Covers
- Safety Glasses
- Outer layer or easily removed protective clothing (as situation requires)

Revision Date: December 17, 2001

This information was prepared by:

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# Radioactive Material Safety Data Sheet

This data sheet presents information on radioisotopes only.
For information on chemical compounds incorporating this radionuclide, see the relevant Material Safety Data Sheet.

## Radium-226

### Part 1 – Radioactive Material Identification

| | | | |
|---|---|---|---|
| **Common Names:** | Radium-226 | **Chemical Symbol:** | Ra-226 or $^{226}$Ra |
| **Atomic Number:** | 88 | **Mass Number:** | 226 (138 neutrons) |
| **Chemical Form:** | Radium bromide or radium chloride | **Physical Form:** | A pellet or solution housed within a ceramic outer-housing. |

### Part 2 – Radiation Characteristics

**Physical half-life:** 1,603 years **Specific Activity (GBq/g):** 36.6

| Principle Emissions | $E_{Max}$ (keV) | $E_{eff}$ (keV) | Dose Rate (µSv/h/GBq at 1m) | Shielding Required |
|---|---|---|---|---|
| Beta* (β) | - | - | - | - |
| Gamma (γ) / X-Rays | 186 (32.8%) | - | 3.3[a] | HVL Lead: 0.04 cm |
| Alpha (α) | 4,785 (94.6%) | - | - | - |
| Neutron (n) | - | - | - | - |

* Where Beta radiation is present, Bremsstrahlung radiation will be produced. Shielding may be required.
Note: Only emissions with abundance greater than 10% are shown.
[a] *The Health Physics and Radiological Health Handbook*, Scintra, Inc., Revised Edition, 1992

**Progeny:** Radon-222 (Ra-222)

### Part 3 – Detection and Measurement

**Methods of detection (in order of preference)**

| |
|---|
| 1. A radiation survey meter equipped with an energy-compensated Geiger Mueller detector. |
| 2. A radiation contamination monitor equipped with a Geiger-Mueller pancake detector. |
| 3. An ZnS(Ag) alpha scintillation detector – must be calibrated to a radium-226 standard before used for a dose assessment survey. |

**Dosimetry**

| Whole Body ☑ | Skin ☐ | Extremity ☐ | Neutron ☐ |
|---|---|---|---|

| | |
|---|---|
| Internal: | Sealed sources pose no internal radiation hazard. However, in the event of loss of containment by the sealed source, all precautions should be taken to prevent inhalation or ingestion of the material. |
| Critical Organ(s): | Bone tissue |
| Annual dose limits: | *Non-nuclear energy workers:* 1mSv per year<br>*Nuclear energy workers:* a) 50 mSv in one year<br>b) 100 mSv total over five years<br>*Pregnant nuclear energy workers:* 4 mSv over the balance of the pregnancy |

**Part 4 – Preventive Measures**

*Always use the principles of time, distance and shielding to minimize dose*

| | |
|---|---|
| Engineering Controls: | Sealed radioactive sources used in industrial applications should always be within a protective source housing to minimize radiation dose and to protect the source capsule from damage. |
| Personal Protective Equipment (*for normal handling of unsealed sources only. Always wear disposable gloves, safety glasses, personal protective equipment and clothing as appropriate to the material handled).*<br>No special PPE required. | |
| Special Storage Requirements: | None |

**Part 5 – Control Levels**

| Oral Ingestion | Inhalation | |
|---|---|---|
| ALI (kBq) | ALI (kBq) | DAC (Bq/ml) |
| 74 | 22.2 | $1.11 \times 10^{-5}$ |
| Exemption Quantity (EQ): | 10,000 Bq | |

**Part 6 – Non-Radiological Hazards**

None identified at this time.

<u>*OSHA Permissible Exposure Limit (PEL)*</u>
No limit set at this time

## Part 7 - Emergency Procedures

*The following is a guide for first responders. The following actions, including remediation, should be carried out by qualified individuals. In cases where life-threatening injury has resulted, **first** treat the injury, **second** deal with personal decontamination.*

### Personal Decontamination Techniques

- Wash well with soap and water and monitor skin
- Do not abrade skin, only blot dry
- Decontamination of clothing and surfaces are covered under operating and emergency procedures

### Spill and Leak Control

- Alert everyone in the area
- Confine the problem or emergency (includes the use of absorbent material)
- Clear area
- Summon Aid

### Damage to Sealed Radioactive Source Holder

- Evacuate the immediate vicinity around the source holder
- Place a barrier at a safe distance from the source holder (min. 5 meters)
- Identify area as a radiation hazard
- Contact emergency number posted on local warning sign

### Suggested Emergency Protective Equipment

- Gloves
- Footwear Covers
- Safety Glasses
- Outer layer or easily removed protective clothing (as situation requires)

Revision Date: December 17, 2001

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## Section 1 - Chemical Product and Company Identification 44

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

## Section 2 - Composition / Information on Ingredients

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

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

**ACGIH TLV**
TWA: 0.1 mg/m$^3$

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

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

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

## Section 3 - Hazards Identification

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

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

**Wilson Risk Scale**

| | |
|---|---|
| R | 1 |
| I | 4 |
| S | 1 |
| K | 0 |

**HMIS**

| | |
|---|---|
| H | 1* |
| F | 0 |
| R | 0 |

*Chronic effects
PPE†
†Sec. 8

### Potential Health Effects

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

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## Section 4 - First Aid Measures

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

## Section 5 - Fire-Fighting Measures

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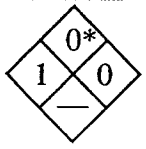


**Flash Point:** Noncombustible as the solid.
**Autoignition Temperature:** None reported.
**LEL:** None reported.
**UEL:** None reported.
**Extinguishing Media:** Use agents suitable for surrounding fire.
**Unusual Fire or Explosion Hazards:** None reported.
**Hazardous Combustion Products:** Silver 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.


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

## Section 9 - Physical and Chemical Properties

**Physical State:** Solid
**Appearance and Odor:** Hard, brilliant white, lustrous, ductile, malleable metal; odorless.
**Vapor Pressure:** 0 mm Hg at 77 °F (25 °C), 100 mm Hg at 3389 °F (1865 °C)
**Atomic Weight:** 107.868
**Density:** 10.5 g/mL
**Thermal Conductivity:** 101 cal/cm/sec/ °C
**Water Solubility:** Insoluble
**Other Solubilities:** Insoluble in most cold acids except dilute nitric acid. Reacts with hot, concentrated sulfuric acid. Soluble in fused alkali hydroxides in the presence of air, fused alkali peroxides, and in alkali cyanides in presence of air or oxygen.
**Boiling Point:** 4013 °F (2212 °C)
**Melting Point:** 1763 °F (961 °C)

## Section 10 - Stability and Reactivity

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

## Section 11- Toxicological Information

### Toxicity Data:*

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

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

## Section 12 - Ecological Information

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

## Section 13 - Disposal Considerations

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

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101): Not listed

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

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

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

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

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

## Section 15 - Regulatory Information

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

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

## Section 16 - Other Information

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

**Strontium Carbonate** **MSDS No. 120**

Date of Preparation: 10/83 Revision: B 10/96

## Section 1 - Chemical Product and Company Identification

48

**Product/Chemical Name:** Strontium carbonate
**Chemical Formula:** $SrCO_3$
**CAS Number:** 1633-05-2
**Synonyms:** carbonic acid, strontium salt; strontianite
**Derivation:** Celestite ore is boiled with a solution of ammonium carbonate or is fused with sodium carbonate.
**General Use:** Used in pyrotechnics, manufacture of iridescent glass, refining sugar, manufacture of ceramic ferrites, glass face plates for color TV tubes; as a chemical intermediate for strontium nitrate, lead scavenger in zinc production, and as flux in production of high-grade alloy steels.
**Vendors:** Consult the latest *Chemical Week Buyers' Guide.* (73)

## Section 2 - Composition / Information on Ingredients

Strontium carbonate, ca > 99 % wt
Trace Impurities: May contain trace amounts of barium carbonate, sulfur, calcium carbonate, magnesium, sodium, silica, or iron.

| OSHA PEL* | ACGIH TLV* | NIOSH REL | DFG (Germany) MAK |
|---|---|---|---|
| 8-hr TWA: 15 mg/m$^3$ (total dust); 5 mg/m$^3$ (respirable fraction) | TWA: 10 mg/m$^3$† | None established | None established |

* As nuisance particulates (not otherwise classified)

† Notice of intended change to 10 mg/m$^3$ (inhalable) and 3 mg/m$^3$ (respirable)

## Section 3 - Hazards Identification

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Strontium carbonate exists as a colorless to white, odorless powder. It has very low order of toxicity due to its poor absorption via the respiratory and gastrointestinal tracts. Ingestion of large amounts may cause nausea and vomiting. It is noncombustible.

| Wilson Risk Scale | |
|---|---|
| R | 1 |
| I | 1 |
| S | 1 |
| K | 1 |

| HMIS | |
|---|---|
| H | 1 |
| F | 0 |
| R | 0 |
| PPE* | |

*Sec. 8

### Potential Health Effects

**Primary Entry Routes:** Inhalation, ingestion.
**Target Organs:** Gastrointestinal tract, teeth; and bones (animals).
**Acute Effects**
**Inhalation:** May cause mechanical irritation of the respiratory tract.
**Eye:** May cause mechanical irritation.
**Skin:** May cause mechanical irritation.
**Ingestion:** Ingestion of large amounts may cause excessive salivation, nausea, vomiting, diarrhea and colic.
**Carcinogenicity:** IARC, NTP, and OSHA do not list strontium carbonate as a carcinogen.
**Medical Conditions Aggravated by Long-Term Exposure:** None reported.
**Chronic Effects:** Strontium in drinking water (13 mg/L) has been shown to cause mineralization of bones and teeth in 1 yr olds. It is not known whether deposition in teeth and bone could be a potential hazard from industrial exposure. Animals chronically exposed to strontium have developed strontium "rickets" (malformation of bone during growth from failure to use calcium and phosphorus normally). Workers in strontium salt plants were reported with decreased cholinesterase activity levels.(190)

## 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 plenty of water. Consult a physician or ophthalmologist immediately.
**Skin Contact:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water followed by a thorough soap and water wash. For reddened or blistered skin, consult a physician.
**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.
***After first aid, get appropriate in-plant, paramedic, or community medical support.***
**Note to Physicians:** Treatment is symptomatic and supportive.

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## Section 5 - Fire-Fighting Measures

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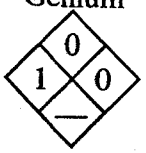


**Flash Point:** Noncombustible.
**Autoignition Temperature:** None reported.
**LEL:** None reported.
**UEL:** None reported.
**Extinguishing Media:** Use agents suitable for surrounding fire.
**Unusual Fire or Explosion Hazards:** None reported.
**Hazardous Combustion Products:** Carbon dioxide and strontium 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:** Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind.
**Small Spills:** Carefully scoop up or vacuum (with HEPA filter) and place in suitable containers.
**Large Spills**
**Containment:** For large spills, dike far ahead of liquid spill for later disposal. Do not release into sewers or waterways.
**Cleanup:** Damp mop any residue.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Use sufficient ventilation to prevent build-up dusts. Cleanup personnel should protect against inhalation.
**Storage Requirements:** Store in a cool, dry, well-ventilated area away from heat sources.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** No special engineering controls are necessary.
**Ventilation:** Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2) for nuisance dusts. Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]
**Administrative Controls:** No specific controls recommended.
**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. Remove strontium carbonate from your shoes and clean personal protective equipment.
**Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using strontium carbonate, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9 - Physical and Chemical Properties

**Physical State:** Solid
**Appearance and Odor:** Colorless to white powder, odorless.
**Formula Weight:** 147.64
**Density ($H_2O$=1, at 4 °C):** 3.5 g/cm$^3$
**Water Solubility:** 11 g/L at 18 °C
**Other Solubilities:** Soluble in dilute acids and ammonium salts.
**Melting Point:** 2727 °F (1497 °C) at 69 atm; decomposes at 2012 °F (1100 °C) into strontium oxide and carbon dioxide.
**Refractive Index:** 1.516, 1.664, 1.666

## Section 10 - Stability and Reactivity

**Stability:** Strontium carbonate is stable at room temperature in closed containers under normal storage and handling conditions.
**Polymerization:** Hazardous polymerization does not occur.
**Chemical Incompatibilities:** None reported.


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**Conditions to Avoid:** Excessive heat.
**Hazardous Decomposition Products:** Thermal oxidative decomposition (at 1100 °C) of strontium carbonate can produce carbon dioxide and strontium oxide.

## Section 11 - Toxicological Information

**Toxicity Data:** Not listed by RTECS*

* Monitor NIOSH, *RTECS* 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):** Not listed

## Section 15 - Regulatory Information

**EPA Regulations:**
RCRA Hazardous Waste (40 CFR 261.33): Not listed
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
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, 136, 190, 197, 209

**Prepared By**.....M Gannon, BA
**Industrial Hygiene Review**.....PA Roy, MPH, CIH
**Medical Review**.....R Teichman, MD

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## Section 1. Material Identification



**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).

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Genium

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* 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$^3$

**1990-91 ACGIH TLV**
**Vanadium, as $V_2O_5$, Respirable Dust and Fume**
TWA: 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)

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

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

* 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 ($VO_x$).

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## Section 6. Hazard Data

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

## Section 7. Spill, Leak, and Disposal Procedures

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

## Section 8. Special Protection Data

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

## Section 9. Special Precautions and Comments

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

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


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*Material Safety Data 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.

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## Section 2. Ingredients and Occupational Exposure Limits

Zinc metal/powder, ca 99%

| OSHA PEL | ACGIH TLV, 1989-90 | NIOSH REL, 1987 | Toxicity Data† |
|---|---|---|---|
| None established* | None established* | None established* | Human, inhalation, $TC_{Lo}$: 124 mg/m³/50 min, pulmonary system effects |

* The current OSHA standard and ACGIH (1989-1990) TWA for zinc oxide (ZnO) fumes is 5 mg/m³. The ACGIH TWA for zinc oxide dust is 10 mg/m³, providing that total contains no asbestos and is <1% crystalline silica. NIOSH has recommended a 10-hr TWA of 5 mg/m³ and a ceiling level of 15 mg/m³ (15-min sample) for zinc oxide fume. The TLV-TWA level was set to prevent metal fume fever.
† See NIOSH, *RTECS* (ZG8600000), for additional data with references to irritative effects.

## Section 3. Physical Data

**Boiling Point:** 907 °F (1663 °C)
**Melting Point:** 419 °F (787 °C)
**Vapor Pressure:** 1 mm Hg at 909 °F (487 °C)
**Brinell Hardness:** 31
**Atomic Weight:** 65.37 g/mol
**Specific Gravity ($H_2O$ = 1 at 39 °F (4 °C)):** 7.13 at 77 °F (25 °C)
**Water Solubility:** Insoluble
**Index of Explosibility, Zn Powder (<0.1 weak, >10 severe):** 0.1

**Appearance and Odor:** Bluish-white lustrous metal, also finely divided forms.

## Section 4. Fire and Explosion Data

**Flash Point:** None reported **Autoignition Temperature:** Cloud, 1256 °F (680 °C);* dust layer, 860 °F (460°C);* powder, 650 mJ* **LEL:** Dust cloud explosion, 0.5 oz/ft³ **UEL:** None reported

**Extinguishing Media:** Use special dry chemical or clean dry sand. *Never* use $CO_2$. Using a direct stream of water may scatter the fire or disperse dust, creating a potentially explosive mixture if exposed to heat or ignition sources. A water spray may be used to cool fire-exposed containers and disperse vapors.
**Unusual Fire or Explosion Hazards:** Flammable hydrogen gas is liberated by reaction with alkali hydroxides (sodium, potassium, and calcium hydroxides), acids, or even water (when material is in dust form) and is an explosion hazard in a confined space. In a fire, zinc may melt, vaporize, and burn to form ZnO fumes (Sec. 2).
**Special Fire-fighting Procedures:** For major fires, or if large quantities of this material are involved, fire fighters should wear appropriate protective clothing and respiratory protection. Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

* Zinc dust refers to the product of zinc vapor condensation, and zinc powder to the product of molten zinc atomization (*Zinc Dust and Zinc Powder: Their Production, Properties, and Applications,* B.C. Hafford, W.E. Pepper, and T.B. Lloyd, 1982). Dust 100% thru 74-µm sieve; a 0.96-J spark can ignite a cloud. The ignition temperature in $CO_2$ is 896 °F (480 °C). The reaction temperature in a nitrogen atmosphere is 1112 °F (600 °C).

## Section 5. Reactivity Data

**Stability/Polymerization:** Zinc is stable in dry air at room temperature. Moist zinc dust can react exothermically and ignite spontaneously in air. Hazardous polymerization cannot occur.
**Chemical Incompatibilities:** Zinc dust is an explosion hazard when reacted with acids, chlorates, oxidizing agents (sulfur and oxygen), halogenated hydrocarbons, hydrazine mononitrate, hydroxylamine, ammonium nitrate, barium dioxide, barium nitrate, cadmium, performic acid, manganese chloride, nitric acid, ethyl acetoacetate and tribromoneopentyl alcohol, tellurium, carbon disulfide, lead azide, magnesium and barium nitrate and barium dioxide, selenium, sodium peroxide, potassium nitrate, and water. In humans, a toxic effect results from inhaling 124 mg/m³ of zinc metal/powder for 50 min.
**Hazardous Products of Decomposition:** Thermal oxidative decomposition of zinc can produce highly toxic fumes. Above 999 °F (537 °C) vaporized zinc burns in air with a blue-green flame to produce zinc oxide fumes.

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## Section 6. Health Hazard Data

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

**Summary of Risks:** Zinc is relatively nontoxic, but when combined with other materials such as oxygen or mineral acids, the resulting compounds can have toxic effects. It is not readily absorbed through the skin, gastrointestinal (GI tract), or lungs. Although most inorganic zinc compounds are potential causes of gastroenteric irritation, a high-level dose is relatively nontoxic when ingested. Zinc is considered essential to life. Ingestion of soluble salts may cause nausea and vomiting, sluggishness, and light-headedness. Inhalation of zinc fumes normally generated by zinc and extreme heat may cause *metal fume fever*, which is accompanied by throat dryness and irritation, coughing, weakness, dyspnea, and generalized aching that generally passes within 24 hr. These symptoms usually begin 3 to 10 hr after exposure and resolve within 24 to 48 hr. Inhalation of zinc dust may cause mild irritation to the upper respiratory tract. Prolonged skin contact with zinc may cause a mild, drying dermatitis.

**Medical Conditions Aggravated by Long-Term Exposure:** Since metallic zinc particulates can be considered a niusance dust, repeated inhalation of zinc dust could lead to respiratory complications.

**Target Organs:** Respiratory system.

**Primary Entry:** Inhalation, ingestion.

**Acute Effects:** Metal fume fever is an acute, self-limiting condition, without recognized complications, aftereffects, or chronic forms. Symptoms appear several hours after exposure. Removal from exposure normally alleviates symptoms with no residual or chronic effects. A degree of tolerance may result from continued exposure, but is quickly lost after a day or two of nonexposure.

**Chronic Effects:** Zinc and zinc powder have little history of causing chronic effects.

**FIRST AID**

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

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

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

**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. If ingested, have that conscious person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear. **Physician's Note:** Calcium disodium edetate ($CaNa_2$-EDTA) has been used medically to increase the rate of zinc removal from the body; however, this usually results from chronic fume exposure or exposure to zinc salts, not to zinc metal powders.

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

## Section 7. Spill, Leak, and Disposal Procedures

**Spill/Leak:** Notify safety personnel of powder spills. Eliminate all heat and ignition sources. Cleanup personnel should protect against dust inhalation and eye contact. Use nonsparking tools for cleanup. Sweep or otherwise place the spilled material in an appropriate, pressure-vented, dry-metal container (with lid) for later disposal. Container should be pressure vented. Avoid creating airborne dust conditions.

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

**OSHA Designations**

Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

**EPA Designations**

RCRA Hazardous Waste (40 CFR 261.33): Not listed

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [* per Clean Water Act, Sec. 307(a)]

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

Zinc (fume or dust) is listed as SARA Toxic Chemical (40 CFR 372.65)

## Section 8. Special Protection Data

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

**Respirator:** For zinc oxide dust or fume concentrations up to 50 $mg/m^3$ and 250 $mg/m^3$, use, respectively, a fume (high-efficiency particulate) respirator or an air-supplied or self-contained respirator with a full facepiece. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.

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

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

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

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

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

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

## Section 9. Special Precautions and Comments

**Storage Requirements:** Store in covered metal containers in a dry, well-ventilated, low fire risk area. Protect containers from physical damage. Never store with acids, halogenated hydrocarbons, or strong alkalis.

**Engineering Controls:** Avoid breathing dust or fumes. Use good housekeeping and cleaning techniques to minimize airborne particulates and to prevent dust accumulation. Provide suitable training in personal hygiene and in the cause and effect of metal fume fever. Prevent exposure of workers with respiratory problems or gastrointestinal disorders.

**Transportation Data (49 CFR 172.102)**

| | |
|---|---|
| **IMO Shipping Name:** Zinc, powder or dust, nonpyrophoric | **IMO Shipping Name:** Zinc, powder or dust, pyrophoric |
| **IMO Hazard Class:** 4.3 | **IMO Hazard Class:** 4.2 |
| **IMO Label:** Dangerous when wet | **IMO Label:** Spontaneously combustible |
| **IMDG Packaging Group:** II | **IMDG Packaging Group:** II |

***MSDS Collection* References:** 2, 4-11, 24, 31, 39-41, 80, 81,84,85,91, 109

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

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# ATTACHMENT 2

# FORMS

TETRA TECH FW, INC.

# DAILY BRIEFING SIGN-IN SHEET

Date: _____ Project Name/Location: _____

Shift/Department: _____ Person Conducting Briefing: _____

**1. AWARENESS (e.g., special EHS concerns, pollution prevention, recent incidents, etc.):**

_____

_____

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_____

**2. OTHER ISSUES (EHS Plan changes, attendee comments, etc.):**

_____

_____

_____

**3. ATTENDEES (Print Name):**

| | |
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# Daily Briefing Sign-In Sheet (Continued)

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Give completed documentation to ESO.

# SITE SAFETY BRIEFING FORM

Site: _____

Date: _____ Time: _____

OFS No.: _____

Task: _____ Health/Safety Officer: _____

Person Providing Briefing: _____

TOPICS:

- Site SHSP
- Chemical Hazards
- Equipment Hazards
- Electrical Hazards
- Heat Stress
- Personal Decontamination
- Personal Hygiene
- Employee Rights/Responsibilities
- Hazard Evaluations
- Emergency Response Procedures

| PERSONS IN ATTENDANCE: (Name/Organization) | PERSONS IN ATTENDANCE: (Name/Organization) |
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NOTES/COMMENTS:

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# FIELD TEAM REVIEW SHEET

Each field team shall sign this section after site-specific training is completed and before being permitted to work on-site.

I have read and understand this **Bae-Wide** Health and Safety Plan for **HUNTERS POINT SHIPYARD, SAN FRANCISCO, CALIFORNIA.**

I will comply with the provisions contained herein.

| Print Name | Signature | Date |
|---|---|---|
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# MEDICAL DATA SHEET

**Project:** _____

**Name:** _____

**Home Telephone Number:** _____

**Home Address:** _____

**Age:** _____ **Height:** _____ **Weight:** _____ **Blood Type:** _____

**Name of Emergency Contact:** _____

**Telephone Number of Emergency Contact:** _____

**Drug or Other Allergies:** _____

**Particular Sensitivities:** _____

**Do you wear contact lenses?** _____

**Provide a checklist of previous illness or exposures to hazardous chemicals:** _____

_____

**What medications are you presently using?** _____

_____

**Do you have any medical restrictions? If yes, explain:** _____

_____

**Name, address, and phone number of personal physician:**

_____

_____

TETRA TECH FW, INC.

***TETRA TECH FW Inc***
***INCIDENT/NEAR MISS REPORT AND INVESTIGATION***

***TYPE OF INCIDENT - CHECK ALL THAT APPLY***

| | | | |
|---|---|---|---|
| ☐ INJURY/ILLNESS | ☐ VEHICLE DAMAGE | ☐ PROPERTY DAMAGE | ☐ FIRE |
| ☐ SPILL/RELEASE | ☐ PERMIT EXCEEDENCE | ☐ HIGH LOSS POTENTIAL (NEAR MISS) | ☐ OTHER |

**1.GENERAL INFORMATION**

PROJECT/OFFICE: REPORT #: DATE OF REPORT:

DATE OF INCIDENT: MILITARY TIME: ____ DAY OF WEEK: ____

FW SUPERVISOR ON DUTY: AT SCENE OF INCIDENT: ☐ YES ☐ NO

LOCATION OF INCIDENT:

WEATHER CONDITIONS: ADEQUATE LIGHTING AT SCENE: ☐ YES ☐ NO ☐ N/A

***DESCRIBE WHAT HAPPENED (STEP BY STEP - use additional pages if necessary)***

***AFFECTED EMPLOYEE INFORMATION***
(Include injured person, driver/operator, or employee whose activities resulted in the incident. Use another page to provide information for additional employees)

NAME: TTFW EMPLOYEE: ☐ YES ☐ NO

HOME ADDRESS:

SOCIAL SECURITY #: HOME PHONE #:

JOB CLASSIFICATION: YEARS IN JOB CLASSIFICATION:

HOURS WORKED ON SHIFT PRIOR TO INCIDENT: YEARS WITH TTFW: AGE:

DID INCIDENT RELATE TO ROUTINE TASK FOR JOB CLASSIFICATION: ☐ YES ☐ NO

***INJURY/ILLNESS INFORMATION***

NATURE OF INJURY OR ILLNESS:

OBJECT/EQUIPMENT/SUBSTANCE CAUSING HARM:

FIRST AID PROVIDED: ☐ YES ☐ NO

IF YES, WHERE WAS IT GIVEN: ☐ ON SITE ☐ OFF SITE

IF YES, WHO PROVIDED FIRST AID:

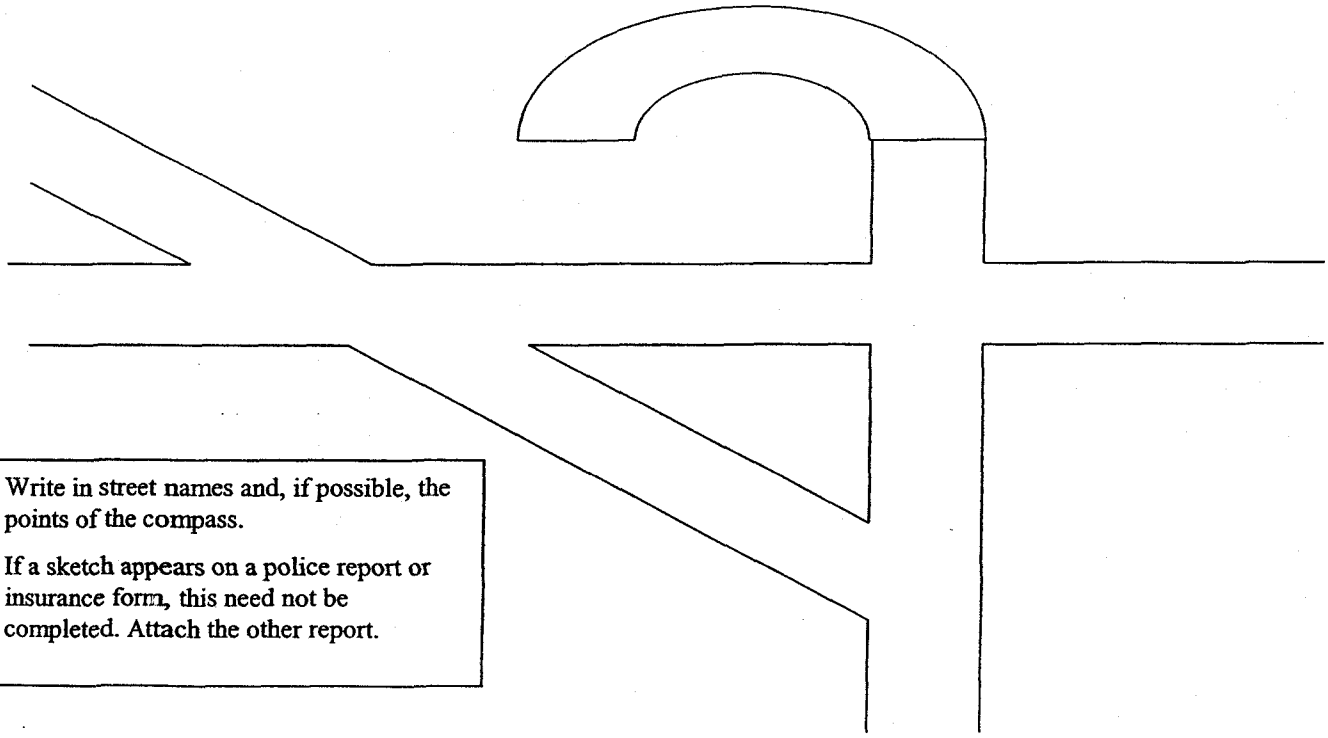
WILL THE INJURY/ILLNESS RESULT IN: ☐ RESTRICTED DUTY ☐ LOST TIME ☐ UNKNOWN

| ***MEDICAL TREATMENT INFORMATION*** | | | |
|---|---|---|---|
| WAS MEDICAL TREATMENT PROVIDED?: | ❒ YES | ❒ NO | |
| IF YES, WAS MEDICAL TREATMENT PROVIDED: | ❒ ON SITE | ❒ DR.'S OFFICE | ❒ HOSPITAL |
| NAME OF PERSON(S) PROVIDING TREATMENT: | | | |
| ADDRESS WHERE TREATMENT WAS PROVIDED: | | | |
| TYPE OF TREATMENT: | | | |
| ***VEHICLE AND PROPERTY DAMAGE INFORMATION*** | | | |
| VEHICLE/PROPERTY DAMAGED: | | | |
| DESCRIPTION OF DAMAGE: | | | |
| ***SPILL AND AIR EMISSIONS INFORMATION*** | | | |
| SUBSTANCE SPILLED OR RELEASED: | FROM WHERE: | TO WHERE: | |
| ESTIMATED QUANTITY/DURATION: | | | |
| CERCLA HAZARDOUS SUBSTANCE? YES ❒ NO ❒ | RQ EXCEEDED? YES ❒ NO ❒ SPECIFY: _____ | | |
| REPORTABLE TO AGENCY? YES ❒ NO ❒ | SPECIFY: _____ | | |
| WRITTEN REPORT? YES ❒ NO ❒ | TIME FRAME: _____ | | |
| RESPONSE ACTION TAKEN | | | |
| ***PERMIT EXCEEDENCE*** | | | |
| TYPE OF PERMIT: | PERMIT #: | | |
| DATE OF EXCEEDENCE: | DATE FIRST KNOWLEDGE OF EXCEEDENCE: | | |
| PERMITTED LEVEL OR CRITERIA (e.g., Water quality): | | | |
| EXCEEDENCE LEVEL OR CRITERIA: | EXCEEDENCE DURATION: | | |
| REPORTABLE TO AGENCY? YES ❒ NO ❒ | SPECIFY: _____ | | |
| WRITTEN REPORT? YES ❒ NO ❒ | TIME FRAME: _____ | | |
| RESPONSE ACTION TAKEN: | | | |
| ***NOTIFICATIONS*** | | | |
| NAME(S) OF TTFW PERSONNEL NOTIFIED: | DATE/TIME: | | |
| CLIENT NOTIFIED: | DATE/TIME: | | |
| AGENCY NOTIFIED: | DATE/TIME: | ❒ NOT REQUIRED | |
| CONTACT NAME: | | | |
| ***PERSONS PREPARING REPORT*** | | | |
| EMPLOYEE'S NAME: (PRINT) | SIGN: | | |
| EMPLOYEE'S NAME (PRINT) | SIGN: | | |
| SUPERVISOR'S NAME: (PRINT) | SIGN: | | |

***NOTE: Supervisor to forward a copy of Incident Report to immediate supervisor, PESM, ESS or ESC, and other personnel as identified in Table 1 of this procedure ASAP, but no later then 24 hours.***

## INCIDENT SKETCH

## VEHICLE INCIDENTS



Write in street names and, if possible, the points of the compass.

If a sketch appears on a police report or insurance form, this need not be completed. Attach the other report.

# *INVESTIGATIVE REPORT*

DATE OF INCIDENT:_____ DATE OF INVESTIGATION REPORT:_____

| | | | |
|---|---|---|---|
| **INCIDENT COST:** | ESTIMATED: $_____ | | ACTUAL: $_____ |
| **OSHA RECORDABLE(S):** | ❒ YES ❒ NO | # RESTRICTED DAYS_____ | # DAYS AWAY FROM WORK_____ |

***CAUSE ANALYSIS***

**Was the activity addressed in an AHA?** ❒ YES (Attach a copy) ❒ NO

**IMMEDIATE CAUSES** – WHAT ACTIONS AND CONDITIONS CONTRIBUTED TO THIS EVENT? (USE NEXT PAGE)

**BASIC CAUSES** - WHAT SPECIFIC PERSONAL OR JOB FACTORS CONTRIBUTED TO THIS EVENT? (USE NEXT PAGE)

***ACTION PLAN***

**REMEDIAL ACTIONS** - WHAT HAS AND OR SHOULD BE DONE TO CONTROL EACH OF THE CAUSES LISTED? INCLUDE MANAGEMENT PROGRAMS (SEE ATTACHED LIST) FOR CONTROL OF INCIDENTS IF APPLICABLE.

| ACTION | PERSON RESPONSIBLE | TARGET DATE | COMPLETION DATE |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

***PERSONS PERFORMING INVESTIGATION***

| | | |
|---|---|---|
| INVESTIGATOR'S NAME: (PRINT) | SIGN: | DATE: |
| INVESTIGATOR'S NAME: (PRINT) | SIGN: | DATE: |
| INVESTIGATOR'S NAME: (PRINT) | SIGN: | DATE: |

***MANAGEMENT REVIEW***

| | |
|---|---|
| PROJECT/OFFICE MANAGER (PRINT) | SIGN: |
| COMMENTS: | |
| PESM or ESC (PRINT) | SIGN: |
| COMMENTS: | |

***NOTE: Attach additional information as necessary. Supervisor to forward copy of Investigative Report to the PM or OM, PESM or ESC ASAP, but no later then 72 hours after the incident. A copy shall be sent to the Director, Environmental Health and Safety Serviceswithin 24 hours of completion of the report.***

## *EXAMPLES OF IMMEDIATE CAUSES*

| SUBSTANDARD ACTIONS | SUBSTANDARD CONDITIONS |
|---|---|
| 1. OPERATING EQUIPMENT WITHOUT AUTHORITY | 1. GUARDS OR BARRIERS |
| 2. FAILURE TO WARN | 2. PROTECTIVE EQUIPMENT |
| 3. FAILURE TO SECURE | 3. TOOLS, EQUIPMENT, OR MATERIALS |
| 4. OPERATING AT IMPROPER SPEED | 4. CONGESTION |
| 5. MAKING SAFETY DEVICES INOPERABLE | 5. WARNING SYSTEM |
| 6. REMOVING SAFETY DEVICES | 6. FIRE AND EXPLOSION HAZARDS |
| 7. USING DEFECTIVE EQUIPMENT | 7. POOR HOUSEKEEPING |
| 8. FAILURE TO USE PPE PROPERLY | 8. NOISE EXPOSURE |
| 9. IMPROPER LOADING | 9. EXPOSURE TO HAZARDOUS MATERIALS |
| 10. IMPROPER PLACEMENT | 10. EXTREME TEMPERATURE EXPOSURE |
| 11. IMPROPER LIFTING | 11. ILLUMINATION |
| 12. IMPROPER POSITION FOR TASK | 12. VENTILATION |
| 13. SERVICING EQUIPMENT IN OPERATION | 13. VISIBILITY |
| 14. UNDER INFLUENCE OF ALCOHOL/DRUGS | |
| 15. HORSEPLAY | |

## *EXAMPLES OF BASIC CAUSES*

| PERSONAL FACTORS | JOB FACTORS |
|---|---|
| 1. CAPABILITY | 1. SUPERVISION |
| 2. KNOWLEDGE | 2. ENGINEERING |
| 3. SKILL | 3. PURCHASING |
| 4. STRESS | 4. MAINTENANCE |
| 5. MOTIVATION | 5. TOOLS/EQUIPMENT |
| | 6. WORK STANDARDS |
| | 7. WEAR AND TEAR |
| | 8. ABUSE OR MISUSE |

## *MANAGEMENT PROGRAMS FOR CONTROL OF INCIDENTS*

| | |
|---|---|
| 1. LEADERSHIP AND ADMINISTRATION | 10. HEALTH CONTROL |
| 2. MANAGEMENT TRAINING | 11. PROGRAM AUDITS |
| 3. PLANNED INSPECTIONS | 12. ENGINEERING CONTROLS |
| 4. TASK ANALYSIS AND PROCEDURES | 13. PERSONAL COMMUNICATIONS |
| 5. TASK OBSERVATION | 14. GROUP MEETINGS |
| 6. EMERGENCY PREPAREDNESS | 15. GENERAL PROMOTION |
| 7. ORGANIZATIONAL RULES | 16. HIRING AND PLACEMENT |
| 8. ACCIDENT/INCIDENT ANALYSIS | 17. PURCHASING CONTROLS |
| 9. PERSONAL PROTECTIVE EQUIPMENT | |

## *NOTIFICATION REMINDER*

**Fatalities or hospitalization (admittance) of three or more individuals requires notification to OSHA within 8 hours. Contact the Director, Health and Safety Programs or Director, ESQ Programs to make the notification. If unavailable, the senior operations person on site should make the notification.**

# Incident/Near Miss Report and Investigation Instructions

**General**: The incident report (pages 1 and 2) must be completed within 24 hours. Do not delay the report if any information is unknown. It can be provided later by revising the Report.

**Type of Incident**: Check all that apply. A High Loss Potential (Near Miss) incident is one that does not result in loss, but under slightly different circumstances, could have resulted in an OSHA Recordable injury, spill, release, permit exceedence, fire, or vehicle/property damage in excess of $500. All High Loss Potential (Near Miss) incidents are to be investigated.

## General Information

**Project/Office:** If the incident occurs on a delivery order contract, give the contract/program name, DO# and location. If the incident occurs on a C&E field project, give the Office location managing the project as well as the project/location.

**Report No.:** Optional numbering field for offices/projects.

**TTFW Supervisor:** The TTFW supervisor responsible for the work effort involving the incident. Do not give a subcontractor supervisor or craft foreman name. If a TTFW Supervisor was the Affected Employee, this field should contain the name of his or her supervisor. The Supervisor is the project supervisor if the incident happens on a project, or the administrative supervisor if the incident happens in the office. E.g., a geologist, acting as an FOL gets injured on a job site, or in a motor vehicle in the course of project work. The FW Supervisor is most likely the Project Manager. If the same geologist gets injured lifting a box in his office, the FW Supervisor is likely the Office Science Lead.

**Location of Incident:** The specific location on the project, in the office, or off-site location.

**Weather Conditions:** Temperature, precipitation, approximate wind speed and direction, cloud cover, relative humidity. This information may be included in the description section, and must be given in detail whenever it is a factor in the cause or impact., e.g., spill, release, heat stress, wind blown material.

**Describe What Happened:** This section must be completed in sufficient detail to adequately describe the events and conditions leading up to and resulting from the incident. Try to answer the questions who, what, where, when, and how. This information is then used to determine why (cause). Provide details such as work objective, procedure being used, body position, and PPE. Include diagrams or sketches for all incidents involving vehicles/equipment and other incidents where they aid in providing detail or perspective. Consider attaching photographs. Follow the guidelines in Practical Loss Control Leadership, and consider the impact of each of the following:

**P** - People
**E** - Equipment
**M** – Material
**E** – Environment

To do an effective job, a visual inspection of the scene is usually necessary along with private interviews of affected employees and witnesses.

Where appropriate, use terms indicating the type of contact, e.g., struck by; struck against; fall from elevation; fall on same level; caught in; caught between or under; caught on; contact with; overstress; equipment failure; environmental release; fire.

## Affected Employee Information

**TTFW Employee:** Direct hire, whether professional, administrative, or craft; full-time or part-time; permanent or temporary. If the affected employee is not a TTFW employee, give the name of the employer and business relationship (e.g., client, subcontractor) in the description section above.

**Hours Worked on Shift Prior to the Incident:** Only include the amount of time the employee worked that shift or day prior to the incident.

**Years with TTFW:** For TTFW employees, give the number of years employed with TTFW. If the employee has worked for TTFW for less than a year, do not write <1. Give the answer in fraction of year, or specify the number of months, e.g., 0.1 or 1 month.

## Injury/Illness Information

**Nature of Injury or Illness:** If the incident resulted in an injury or illness, give a brief description of the body part affected and type of injury or illness, e.g., fractured thumb, left hand; carpal tunnel syndrome, right hand.

**First Aid Provided:** First Aid is any treatment that does not have to be provided by a health care professional, even if it is. E.g., a laceration that is cleaned and bandaged in a clinic may constitute first aid, if sutures are not given.

**Will the Injury Result In:**. Do not delay the report if this information is unknown.

## Medical Treatment Information

**Was Medical Treatment Provided?** Medical treatment is that treatment that must be provided by a licensed medical practitioner, e.g., sutures, prescription medication, etc.

**Type of Treatment:** This information is important in determining OSHA recordability, since some forms of treatment would not constitute a Recordable case (e.g., one-time administration of prescriptions, negative diagnostic exams). Attach a copy of the treating professional's statement/work release.

## Vehicle and Property Damage Information

**Vehicle/Property Damaged:** For vehicles, indicate VIN and whether it is company owned or leased, business trip rental (Avis) or owned by others.

**Description of Damage:** Be specific as to the identity of damaged part, location and extent.

## Spill and Air Emissions Information

**Substance Spilled or Released:** For pure substances, list materials by common name/chemical. For wastes, indicate waste code. For mixtures or contaminated media, provide contaminant name, CAS No., concentration.

**RQ Exceeded?** Reportable quantity. Contact your ESQ representative for guidance. Specify the RQ for the material, whether you answer yes or no.

**Reportable to Agency?** If yes, specify the federal, state or local agency that must be provided with verbal and/or written notification.

**Written Report?** Answer yes if the release requires a written report to be filed and note the time frame.

**Response Action Taken:** Describe the mitigation efforts, as well as any reports made, beyond initial notification.

## Permit Exceedence

**Type of Permit:** List name of permit including the agency name where applicable (e.g., NPDES, PSAPCA NOC)

**Date of Exceedence:** Specify date exceedence occurred (e.g., date discharge in excess of permit limits occurred)

**Date First Knowledge of Exceedence:** Specify date when first knew there was an exceedence (i.e., date analytical received). This date may be different from the date of the exceedence listed above.

**Permitted Level or Criteria:** List numerical discharge or emission limit or narrative criteria specified in the permit (e.g., 20% opacity limit, Best Management Practices (BMP) implementation per SWPPP).

**Exceedence Level or Criteria:** Specify actual numerical discharge/emission limit or narrative criteria which was exceeded (e.g., 22% opacity, failure of BMPs (silt fencing collapse) per SWPPP)

**Exceedence Duration:** Specify time frame by date and hours (using military time) during which exceedence occurred.

See "**Spill/Release Information**" (above) for description of remaining questions.

## Persons Preparing Report

**Employee's Name:** The affected employee described on page 1 should review the report and sign here, as well as other employees witnessing or involved in the incident.

**Supervisor's Name:** The TTFW Supervisor must review and sign the report indicating agreement. The TTFW Supervisor and the Investigator (next page) should be the same person.

## Investigative Report

**Report No.:** This is the same as the project/office optional report number from page 1 of the Incident/Near Miss Report.

**Date of Investigative Report:** This date should be within 72 hours of the incident. In cases where the investigation is not completed until a later date, submit the incomplete report within the 72 hours, and a revised report should be submitted when the missing information is obtained.

**Incident Cost:** For all vehicle/equipment or property damage cases, an estimated or actual loss value must be entered. If an estimated value is entered, the report must be revised when the actual costs are known.

**OSHA Recordables:** This section should be completed in consultation with the PESM. If it cannot be determined at the time of the report, the PESM should consult with the Director, Health and Safety Programs and revise the report when a determination is made.

**No. of Restricted Days:** This relates to days of restricted work activity, not restrictions on motion or physical capability. If the employee is capable of doing his normal job the day after the injury and thereafter, there are no restricted days, even if the physician indicates a physical restriction. It does not include the day of the injury.

**No. of Days Away from Work:** The number of days after the day of the injury that the employee was scheduled to work but could not due to an occupational injury. If the treating physician releases an employee to return to work, but the employee chooses not to come to work, do not count those

days. In this case the PESM should contact the Director, Health and Safety Programs.

## Cause Analysis

**Immediate Causes:** Determine the immediate causes, using the example on page 4. If one or more of the examples fits the circumstance, use those words in the cause description. This facilitates statistical analysis of the incident database for program evaluation/modification. However, do not confine your cause determination to the guide words. Explain, e.g., Improper Lifting – employee attempted to lift box by bending at the waist and twisting while lifting. Be sure that the incident description on page 1 is sufficiently detailed to support the causal analysis in this section. An assumption of cause (e.g., improper lifting) from the injury (low back pain) is not acceptable.

**Basic Causes**: Like the Immediate Causes, use the guide words in the attachment whenever appropriate and explain. For example, improper motivation may be because the correct way takes more time or effort; short cutting standard procedure is tolerated or positively reinforced; or the person thinks there is no personal benefit to always doing the job correctly.

**Note:** The investigator is encouraged to review the Practical Loss Control Leadership chapters on *Causes and Effects of Loss* and *Accident/Incident Investigation* before doing the causal analysis. As a check, the investigator may refer to the P.C.A.T. Chart available from the PESM.

**Remedial Actions:** Include all actions taken or those that should be taken to prevent recurrence. Be sure that actions address the causes. For example, training (safety meetings) may be a necessary response for lack of knowledge, but may be inadequate for improper motivation. If completion dates exceed the 72 hours reporting period, a revised report must be submitted when all remedial actions are complete.

**Persons Performing Investigation:** The primary investigator is the TTFW Supervisor in charge of the work where the incident occurred. Others participating in the investigation, such as the Project Manager, ESS, QC, site engineer, foreman, etc. should also sign the report.

**Management Review:** The Project or Office Manager and the PESM or office ESC must sign the report indicating their satisfaction with thoroughness of the investigation and the report, and their concurrence that the action items address the identified causes. This constitutes the peer review, and the report, particularly the description, should be clear to readers not familiar with the project or incident.

TETRA TECH FW, INC.

# SITE SAFETY PLAN CHANGE APPROVAL FORM

N68711-98-D-5713 CTO: _____

Date _____ Amendment Number _____

Project Name: _____ Project Number: _____

Section of SHSP: _____ Page Number: _____

Change to read: _____

_____

_____

_____

_____

_____

_____

Reason for change: _____

_____

_____

_____

_____

_____

_____

Approvals: _____

Project Superintendent or Manager

_____

SSHS

_____

PESM (CIH)

# SAFETY INSPECTION CHECK LIST FOR CONSTRUCTION EQUIPMENT

*(Including Cranes, Derricks, and Hoisting Equipment)*

| PROJECT | CONTRACTOR | CONTRACT NO. |
|---|---|---|
| TYPE AND MAKE OF EQUIPMENT | MODEL | SERIAL NO. |

Before any machinery or mechanized equipment is placed in use, it shall be inspected and tested by a competent mechanic and certified to be in good operating condition. Records of tests and inspections shall be maintained as part of the active contract file at Project or Resident Office. Check list set forth herein requires the application of EM 385-1-1, Safety and Health Requirements Manual, 1 Oct 87. The appropriate EM paragraph to be applied is listed at the end of each testing requirement.

| CHECK LIST | Yes | No | Not Appl |
|---|---|---|---|
| 1. ARE ADEQUATE AND SERVICEABLE FIRE EXTINGUISHERS PROVIDED? (13.A.01) | | | |
| 2. ARE ALL WIRE ROPE CABLES IN GOOD CONDITION? (17.C.01) | | | |
| 3. ARE WIRE ROPE, SOCKETS, SPLICES, THIMBLES AND CLIPS ADEQUATE AND PROPERLY APPLIED? (17.C.09) | | | |
| 4. ARE HOOKS, SAFETY HOOKS, SHACKLES, RINGS, ETC., IN GOOD CONDITION? (17.A.02, 17.A.05) | | | |
| 5. ARE NECESSARY PLATFORMS, FOOTWALKS, ETC., PROVIDED? (18.B.08) | | | |
| 6. ARE ACCESS STEPS, PLATFORMS, ETC., PROVIDED WITH NON-SLIP SURFACES? (18.B.08, 19.A.14, (26.B.03) | | | |
| 7. IS OPERATOR PROTECTED AGAINST THE ELEMENTS, FALLING OR FLYING OBJECTS, SWINGING LOADS, AND SIMILAR HAZARDS? (18.B.18, 19.A.13, [illegible] 18.B.19, 18.B.21) | | | |
| 8. ARE ALL GLASSES IN OPERATOR'S COMPARTMENT SAFETY GLASS AND IN GOOD REPAIR? (19.A.15, 19.A.16, 18.B.18) | | | |
| 9. IS SUITABLE ACCESS PROVIDED TO LUBRICATION POINTS? (18.A.18) | | | |
| 10. DO ALL MODIFICATIONS, EXTENSIONS, REPLACEMENT PARTS, AND/OR REPAIRS TO EQUIPMENT MAINTAIN THE SAME FACTOR OF SAFETY AS ORIGINAL DESIGNED EQUIPMENT? (18.A.33, 18.C.04) | | | |
| 11. ARE DRUMS FOR LOAD LINES EQUIPPED WITH AT LEAST ONE POSITIVE HOLDING DEVICE, APPLIED DIRECTLY TO THE MOTOR SHAFT OR SOME PART OF THE TRAIN GEAR? (18.C.06) | | | |
| 12. IS THERE SUFFICIENT CABLE TO ALLOW TWO FULL WRAPS OF CABLE ON DRUMS AT ALL WORKING POSITIONS? (18.C.07) | | | |
| 13. ARE ADEQUATE HEADLIGHTS, TAIL-LIGHTS AND TURN SIGNALS PROVIDED AND ARE THEY IN PROPER OPERATING CONDITION? (19.A.06, 18.A.15) | | | |
| 14. ARE ALL APPROVED BRAKES ON WHEELED EQUIPMENT AND IN GOOD OPERATING CONDITION? (18.A.21, 18.A.22, 19.A.07, 19.A.08) | | | |
| 15. DO WINDSHIELDS HAVE WIPERS IN PROPER OPERATING CONDITION? (19.A.10, 18.A.29) | | | |
| 16. ARE REAR VIEW MIRRORS PROVIDED? (19.A.12) | | | |
| 17. ARE OPERATING LEVERS EQUIPPED WITH LATCH OR OTHER DEVICES TO PREVENT ACCIDENTAL STARTING? (19.A.21) | | | |

| DRILLING EQUIPMENT | |
|---|---|
| Contract Name and Number: | Contractor/Subcontractor: |
| Government Inspector: | Location: |
| Contractor Inspector: | Date: |
| Equipment name and number: | |

| | Yes | No | N/A |
|---|---|---|---|
| 1. Is a copy of the manual for all drilling equipment available? (16.M.02) | | | |
| 2. Has a survey been conducted to identify overhead electrical hazards and potential ground hazards and their locations identified in the site layout plan? (16.M.03) | | | |
| 3. Does the hazard analysis contain copies of Material Safety Data Sheets for all drilling fluids available? (16.M.03a) | | | |
| 4. Have all members of the drilling crew been trained the operation, inspection, and maintenance of the equipment; the safety features and procedures to be used; and overhead electrical lines and underground hazards? (16.M.04a) | | | |
| 5. Does the drilling equipment have two easily accessible emergency shut down devices (one for the operator and one for the helper)? (16.M.05) | | | |
| 6. Is the equipment posted with a warning of electrical hazards? (16.M.06a) | | | |
| 7. Is there a spotter or an electrical proximity warning device available to ensure safe distances from power lines are maintained? (16.M.06b) | | | |
| 8. Before moving earth drilling equipment, has the travel route been surveyed for overhead and terrain hazards, particularly overhead electrical hazards? (16.M.07a) | | | |
| 9. Is equipment set-up in a stable manner, with cribbing if necessary? (16.M.08a) | | | |
| 10. Are outriggers being used in accordance with the manufacturer's recommendations? (16.M.08b) | | | |
| 11. Are drill crew members prohibited from wearing loose clothing, jewelry, or equipment which might become caught in moving machinery? (16.M.09b) | | | |
| 12. Are steps being taken to control dust? (16.M.09i) | | | |
| 13. Are augers cleaned only when the rotating mechanism is in neutral and the auger is stopped? (16.M.09j) | | | |
| 14. Means shall be provided to guard against employee contact with auger. (guard around the auger; barricade around the perimeter of the auger; electronic brake activated by a presence-sensing device). 16.M .10l | | | |

Comments:

This checklist is based on EM 385-1-1, dated 3 September 1996. Use of this checklist is optional.

| MACHINERY AND MOBILE EQUIPMENT (BACKHOES, DOZERS, SCRAPERS, EXCAVATORS, LIFT TRUCKS, etc.) | |
|---|---|
| Contract Name and Number: | Contractor/Subcontractor: |
| Government Inspector: | Location: |
| Contractor Inspector: | Date: |
| Equipment name and number: | |

| **Complete one checklist for each piece of equipment.** | **Yes** | **No** | **N/A** |
|---|---|---|---|
| 1. Is the slow moving emblem used on all vehicles which by design move at 25 mph or less on public roads? (08.A.04) | | | |
| 2. Are initial and daily/shift inspection records available? (16.A.01 and .02) | | | |
| 3. When machinery or equipment is found to be unsafe or when a deficiency which affects the safe operation of equipment is observed, is the equipment immediately taken out of service and its use prohibited until unsafe conditions have been corrected? (16.A.03) | | | |
| 4. Is machinery or equipment operated only by designated personnel? (16.A.04) | | | |
| 5. Have inspections or determinations of road conditions and structures been made in advance to assure that clearances and load capacities are safe for the passage or placing any machinery or equipment? (16.A.06) | | | |
| 6. Are seats or equal protection provided for each person required to ride on the equipment? (16.A.07a) | | | |
| 7. Is equipment operating on streets and highways equipped with headlights, tailights, brake lights, back light, and turn signals (visible from front and rear)? (16.A.07b) | | | |
| 8. Is all equipment equipped with operable windshield wipers, and defrosting or defogging equipment? (16.A.07c) | | | |
| 9. Does the unit have an emergency brake which will automatically stop the equipment upon brake failure? Is this system manually operable from the drivers position? (16.A.07d) | | | |
| 10. Is all maintenance (including preventive maintenance) and repairs done in accordance with the manufacturer's recommendations and is it documented? (16.A.08a) | | | |
| 11. Has bulldozer and scraper blades, end-loader buckets, dump bodies, and similar equipment been fully lowered or blocked when being repair or when not in use? (16.A.09) | | | |
| 12. Has adequate ventilation been provided when equipment powered by internal combustion engines is operating in enclosed areas? (16.A.12) | | | |
| 13. Are all vehicles which will be parked or moving slower than normal traffic on haul roads equipped with a yellow flashing light or flasher visible from all directions? (16.A.13) | | | |
| 14. Is all mechanized equipment shut down before and during refueling? (16.A.14) | | | |
| 15. Are all towing devices used on any combination of equipment structurally adequate for the weight drawn and securely mounted? (16.A.15a) | | | |
| 16. Have the wheels been chocked or track mechanisms blocked and the parking brake set when equipment is parked on an incline? (16.A.17b) | | | |

This checklist is based on EM 385-1-1, dated 3 September 1996. Use of this checklist is optional.

## MACHINERY AND MOBILE EQUIPMENT (con.)

| | Yes | No | N/A |
|---|---|---|---|
| 17. Are personnel prohibited from working or passing under or riding in the buckets or booms of loaders in operation? (16.A.24) | | | |
| 18. Does the unit have a dry chemical or carbon-dioxide fire extinguisher with a minimum rating of 5-B:C? (16.A.26) | | | |
| 19. Is there an effective, working reverse alarm? (16.B.01) | | | |
| 20. Is there a signalperson or warning device when there is a danger to persons from moving equipment, swinging loads, buckets, booms, etc.? (16.B.02) | | | |
| 21. Are all belts, gears, shafts, pulleys, sprockets, spindles, drums, flywheels, chains, or other reciprocating, rotating, or moving parts guarded? (16.B.03a) | | | |
| 22. Is protection against hot surfaces, exhausts, etc., provided? (16.B.03b) | | | |
| 23. Are platforms, footwalks, steps, handlholds, guardrails, and toeboards designed, constructed, and installed on machinery and equipment to provide safe footing and accessways? (16.B.03d) | | | |
| 24. Are fuel tanks located in a manner to prevent spills or overflows from running onto engine exhaust or electrical equipment? (16.B.04) | | | |
| 25. Are exhaust or discharges from equipment directed so they do not endanger persons or obstruct operator vision? (16.B.05) | | | |
| 26. Are seatbelts installed and worn in all motor vehicles? (16.B.08) | | | |
| 27. Is protection (grills, canopies, screens) provided to shield operator from falling or flying objects? (16.B.10 and .11) | | | |
| 28. Is roll over protection provided? (16.B.12) | | | |
| Comments: | | | |

This checklist is based on EM 385-1-1, dated 3 September 1996. Use of this checklist is optional.

# MACHINERY & MECHANIZED EQUIPMENT CERTIFICATION FORM

From: (Contractor)

(Sub-Contractor)

Contract No._____Title:

To: Contracting Officer/ROICC COTR

Subj: **SAFETY CERTIFICATION OF MACHINERY AND MECHANIZED EQUIPMENT**

Ref: (a) U. S. Army Corps of Engineers, EM 385-1-1
Safety and Health Requirements Manual

1. Inspection and certification of machinery and mechanized equipment, as required by reference (a) has been made as shown below:

a. Identification of equipment

(1)_____ Date

(2)_____ Date

(3)_____ Date

(4)_____ Date

(5)_____ Date

2. The above listed equipment is CERTIFIED TO BE IN SAFE OPERATING CONDITION BY A COMPETENT PERSON and as outlined in reference (a).

Name, Title, and signature of competent mechanic making the inspection:

Name_____ Title

Firm

Signature

Copy to :
Contract File

# ATTACHMENT 3

# RADIATION PROTECTION PROGRAMS AND POLICIES

# RP1-1: Radiological Protection Program

Purpose
To establish the radiological protection program for operations involving radioactive material or for providing access to radiological areas.

| | |
|---|---|
| Version Date: | 12/12/2001 - New |
| Original Issue Date: | 12/12/01 |
| Department/Category: | Radiological Protection Procedure |
| Document Type: | Procedure |
| Keyword Index: | radiological protection, radiation, radioactive materials |
| Approved by: | |

## 1.0 PURPOSE

The purpose of this procedure is to define Tetra Tech FW, Inc. (TtFW) requirements for radiological protection.

## 2.0 SCOPE

This procedure applies to work involving the use and/or handling of radioactive material or work in areas controlled for the purposes of radiation protection. This procedure may not meet all of the requirements for projects involving naturally occurring radioactive materials, or for projects regulated by a host state. In these cases a review of the applicable regulations is needed during project planning.

## 3.0 MAINTENANCE

The Director, Environmental, Safety and Quality (ESQ) Programs is responsible for updating this procedure. Approval authority rests with TtFW's President and Chief Executive Officer. Suggestions for revision will be submitted to both the department responsible for updating the procedure and the Executive Director, Administration and Compliance.

## 4.0 DEFINITIONS

See RP1-2, Glossary of Radiological Protection Terms.

## 5.0 DISCUSSION

### 5.1 Responsibilities

#### 5.1.1 Line Management

Line management is responsible for the implementation of and compliance with the requirements of the TtFW Radiological Protection Program (RPP) and applicable TtFW Radiation Protection procedures.

Line Management is responsible for forwarding any Task Initiation Procedure (TIP) or modified TIP reviews for proposed projects involving exposure to ionizing radiation or radioactive material to the Director, Health Physics Programs, for input/approval. Involvement includes the use of subcontractors who may use radioactive material or radiation generating devices in the course of their work, such as field radiography, the use of soil density gauges, well logging, etc.

The Project Manager shall ensure that project personnel have education, training and skills commensurate with the radiation hazards involved.

#### 5.1.2 Field Personnel

Field personnel include all TtFW and subcontractor personnel on the job site. All field personnel who have the potential to receive occupational exposure to radiation will receive adequate

radiation training prior to beginning the work (RP2-11, Radiation Safety Training). Field personnel will comply with requirements of the RPP and applicable Radiation Protection procedures. All personnel have the responsibility to report radiological safety issues or concerns, including incidents and unplanned events, immediately to project management and ESQ staff.

### 5.1.3 Health Physics Personnel

The Director, Health Physics Programs is appointed by the Director, ESQ Programs to be the senior health physicist for TtFW. The Director, HPP is responsible for reviewing project plans, which involve the use, or handling of radioactive materials, or access to radiological areas to ensure compliance with the requirements of this procedure. Working with the Environmental, Safety and Quality (ESQ) Resource Managers, the Director, HPP will assign an individual who will serve as Project Health Physicist (PHP) to provide day-to-day guidance on radiological protection issues. The Director, HPP reviews and recommends revisions to this procedure and applicable Radiation Protection procedures.

The Director, HPP or designee has responsibility for:

- Serving as the Resource Specialist for Task Initiation Procedure (TIP) review for proposed projects involving exposure to radiation or radioactive material;
- Assisting with the development of site Environmental, Health and Safety (EHS) plans and approving EHS plans for projects which involve the use or handling of radioactive materials or access to radiological areas;
- Ensuring appropriate project staffing to implement the requirements of this program;
- Providing guidance to TtFW personnel on radiological protection issues;
- Performing the program audits defined in A-21, Audits;
- Developing or approving radiation safety training materials or courses; and
- Maintaining radiological exposure records.

The Director, HPP may delegate project responsibilities to other TtFW Certified Health Physicists (CHPs). However, the individual who assists with the development of the site EHS plan and who is an approver of the site EHS plan(s) will be the PHP.

The PHP is responsible for:

- Assisting in the development of the site EHS plan, and approving the plan;
- Assisting in identifying project radiological analyses needs and identifying/selecting analytical contractors;
- Providing health physics guidance on an as-needed basis;
- Providing radiological control/protection technician services;
- Conducting required radiological safety training;
- Reviewing and approving project field procedures which involve the handling of radioactive materials or access to radiological areas;
- Conducting radiation incident investigations;
- Conducting radiological project inspections; and
- Arranging for and assisting in program radiation protection audits defined in TtFW Corporate Procedure A-21, "Audits."

Note: Audit frequency should be annual for all projects not associated with a DOE contract. If a DOE contract is involved, then the audit frequency should be 1/3 of program elements annually such that all elements are reviewed every three years.

### 5.1.4 Environmental, Health, and Safety Personnel

The Project Environmental and Safety Manager (PESM) is responsible for ensuring that all EHS plans for projects involving potential exposure to radioactive materials or access to radiological areas are reviewed and approved by the Director, HPP or their designee.

The Environmental and Safety Supervisor (ESS) is responsible for:

- Assisting in the implementation of the radiological protection requirements specified in the EHS plans and this program; and
- Maintaining a project site file of radiological protection training, dosimetry records, radiological surveys, radiological incident investigations, and other documentation pertinent to this program and the EHS plans and providing copies to the Director, ESQ Programs at the conclusion of the project.

### 5.1.5 Procurement Personnel

Procurement personnel are responsible to ensure that all procurements related to the following are approved by the Director, Health Physics Programs prior to procurement:

- Radioactive material;
- Radiation producing devices;
- Dosimetry services (thermoluminescent dosimeters, bioassay analyses, whole body counting services);
- Portable radiological instrumentation;
- Fixed radiological instrumentation; and
- Subcontractors who may use radioactive material or radiation generating devices in the course of their work, such as field radiography, soil density gauges, well logging, etc.

## 5.2 General Requirements

The policies in this procedure establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation.

The requirements of the TtFW radiological protection program procedures do not apply to:

- Activities conducted outside the United States on territory under the jurisdiction of a foreign government to the extent governed by occupational radiation protection requirements agreed to between the United States and the cognizant government; or
- Background radiation, radiation doses received as a patient for the purposes of medical diagnosis or therapy, or radiation doses received from participation as a subject in medical research programs.

Nothing in the Tetra Tech FW, Inc. Radiation Protection Plan (RPP) will be construed as limiting actions that may be necessary to protect health and safety.

TtFW's involvement in the use or handling of radioactive materials occurs under the authority of the Nuclear Regulatory Commission (NRC), or the Department of Energy (DOE), the U.S. Corps of Engineers (USACE), or other customer-owned programs. TtFW has established baseline radiological protection objectives and requirements against which applicable NRC, DOE, USACE, or other customer programs are assessed to ensure TtFW employees are being provided a level of protection against radiological health risks commensurate with Corporate EHS Policy.

The requirements contained in this procedure will be implemented in addition to any requirements imposed by client programs. However, specific elements of a client's program may be

implemented in lieu of TtFW's if the client program requirements are deemed to provide the same or greater level of protection. The decision to substitute client requirements will be made on a case-by-case basis by the PHP with concurrence of the Director, HPP. The site-specific EHS plans will document such approval.

### 5.2.1 Education, Training and Skills

Individuals working on a site where radiation or radioactive materials are present above natural background shall have education training and skills appropriate to the discharge of their responsibilities. Training requirements for the project shall be documented in the EHS plan and approved by the PHP. The following table suggests training appropriate for various kinds of project activities.

| PROJECT ACTIVITY | RECOMMENDED TRAINING | | | | |
|---|---|---|---|---|---|
| | Project Orientation | GERT See RP2-11 | RWT See RP2-11 | RCT See RP2-11 | Other |
| Management/Supervision | X | X | | | * |
| Direct Responsibility for Radiation Protection | X | X | X | ** | * |
| Use of Radioactive Materials | X | X | X | | * |
| Making Radiation Measurements | X | X | | | * |
| Clerical | X | | | | * |

* Subject to agreement of the PM and the PHP.
** Depending on the complexity of the project and the recommendation of the PHP.

### 5.2.2 Written Procedures

This procedure is supplemented by RP1-2, Glossary of Radiological Protection Terms, RP1-3, Regulatory Requirements Implementation, and the following radiological protection implementing procedures:

- RP2-1: As Low As Reasonably Achievable (ALARA) Program – Provides requirements for maintaining radiological impact to workers, the public and environment ALARA.
- RP2-2: Standards for Internal and External Radiation Exposure – Provides radiation dose limits for personnel working on TtFW projects.
- RP2-3: Radiological Monitoring of Individuals and Areas – Provides requirements for monitoring personnel for external and internal exposure to radiation or radioactive material.
- RP2-4: Radiological Entry Control Program – Provides requirements for entry to radiologically posted areas.
- RP2-5: Radiological Posting and Labeling – Provides requirements for posting and/or labeling of radioactive materials or radiologically controlled areas.
- RP2-6: Respiratory Protection for Radiological Activities – Provides requirements for use of respiratory protection in radiological areas.
- RP2-7: Radioactive Contamination Control – Provides requirements for control of radioactive contamination.
- RP2-8: Radiological Protection Records – Provides requirements for the maintenance

and retention of radiological protection records.

- RP2-9: Reports to Individuals – Provides requirements for reporting of radiation exposure to individuals.
- RP2-11: Radiation Safety Training – Provides requirements for radiological training of site personnel.
- RP2-12: Radiological Design and Control – Provides requirements for design and control of radiological facilities.
- RP2-13: Sealed Radioactive Source Control – Provides requirements for the control of sealed radioactive sources.
- RP2-14: Emergency Exposure Situations – Provides requirements for emergency exposure situations at DOE facilities.
- RP2-15: Environmental Radiation Protection – Provides requirements for monitoring radioactive emissions, and release of equipment and property.
- RP2-16: Radiological Criteria for NRC or Agreement State License Termination – Provides requirements and guidance for NRC or Agreement State license termination.
- RP2-17: Radioactive Waste Disposal – Provides requirements for characterizing and disposal of radioactive waste from an NRC or Agreement State license.
- RP2-18: Radiological Incident Reporting – Provides requirements for ensuring compliance to DOE and NRC reporting requirements.

These procedures provide a general requirements for implementation of a radiation protection program. When necessary a third (lower) tier of radiological protection documents may be developed and implemented to support compliance with this procedure. This level of procedure details how to perform activities, such as taking soil samples, performing radiological surveys, etc., and may be designated RP3-XX.

### 5.3 Stop Work Authority

TtFW and subcontractor personnel shall have the responsibility and authority to stop radiological work when radiological controls are inadequate.

In any situation in which stop work authority is used, the following requirements shall apply:

- Exercise stop work authority in a justifiable and responsible manner;
- Once work is stopped, do NOT resume until proper radiological controls have been established; and
- Resumption of work shall require concurrence by the PHP and the Project Manager, or Site Manager, as appropriate.

### 5.4 Records

Records will be retained in accordance with RP2-8, Radiological Protection Records.

## 6.0 REFERENCES

### 6.1 Department of Energy

10 CFR 835, Occupational Radiation Protection
DRAFT DOE Guide 414.2A, Implementation Guide for Use with 10 CFR 830.120 and DOE Order

5700.6C, Quality Assurance
DOE Guide 441.1-1, Implementation Guide for Management and Administration of Radiation Protection Programs
DOE Order 414.1, Quality Assurance
DOE Order 5400.5, Radiation Protection of the Public and the Environment
DOE-STD-1107-97, Knowledge, Skills and Abilities for Key Radiation Protection Positions at DOE Facilities

## 6.2 Nuclear Regulatory Commission

10 CFR 19 Notices, Instructions and Reports to Workers: Inspection and Investigations
10 CFR 20, Standards for Protection Against Radiation

## 6.3 TtFW Corporate Reference Library Procedures

Administrative Procedure A-21, Audits.
Radiological Protection Program Procedure, See Section 5.2.2 for reference procedures.

**Tetra Tech FW, Inc.**

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# RADIATION PROTECTION PROGRAM
For
# HUNTERS POINT SHIPYARD

## *1.0 Introduction*

This document describes the Radiation Protection Plan for site work performed by Tyetra Tech FW at Hunters Point Shipyard, San Francisco, California. This radiation protection plan is a generic plan to be used as an addendum or an example of a program that will be part of each Site Specific Health and Safety Plan. It provides for the radiological protection of personnel working on site and ensures compliance with the applicable NRC, federal and state regulations.

### 1.1 Purpose

Previous studies at HPS have found radioactive point sources, chiefly consisting of dials and other objects painted with radium paint (Radium-226) and other radioactivity. The Navy has required project management to implement a plan to assure that radioactive material is not removed from the site and that if there is radioactive material that such material will be managed appropriately. Radiation protection and the use of this plan for those purposes ss required at the time radioactive materials are identified by means of the radiological screening survey.

### 1.2 Applicability

This plan applies to all Tetra Tech FW personnel and subcontractors on the project. This plan is in effect until site characterization operations are complete at the site.

## *2.0 References*

- Code of Federal Regulations, Title 29, Section 1910.96, *Ionizing Radiation*
- California Code of Regulations, Title 8, Article 102 and Title 17, Chapter 5, Subchapter 4 (commencing at Section 30100) of the California Administrative Code
- Tetra Tech FW Radiological Protection Programs:
  - RP1-1 Radiological Protection Program
  - RP3-32 Radiation Surveys
  - RP3-33 Contamination Surveys
  - RP3-36 Shipment and Transporting of Radiological Instrument Check Sources
  - RP3-37 Portable Radiation Detection Instrumentation Operational Checks
  - RP3-38 Radiological Screening Surveys

## *3.0 Radiation Safety Organization and Responsibilities*

Tetra Tech FW is committed to maintaining a radiation protection program for the protection of Tetra Tech FW employees, subcontractor personnel, visitors to the site, and the general public. Every individual involved in work within the restricted area has the responsibility for radiation safety and proper performance of their assigned operational duties. This section describes these basic responsibilities.

### *3.1 Radiation Protection Organization*

The organizational lines and responsibilities for radiation protection originate with the individual worker and go through the ESS (SHSS) to the Project Manager, the Program Manager, the Program Environmental Safety Manager (CIH), the Director, Health Physics Programs (CHP) and the Director, Environmental Health and Safety Services.

### 3.1.1 Project Manager

The project manager (PjM) has overall responsibility for assuring that the work is conducted in accordance with requirements of the contract. The PjM is responsible for communication and information exchange with the client and concerned regulatory organizations. The PjM's radiological protection responsibilities are:

- Be aware of the radiological exposure conditions for the job tasks under his/her direction.
- Ensure that the personnel under his/her direction are provided with the proper radiation protection training and have the specific knowledge concerning the details of the job assignment
- Ensure that the personnel under his/her direction adhere to the radiological protection rules, regulations, and procedures. Counsel and/or recommend re-training or disciplinary action for those personnel who violate radiological protection rules, regulations or procedures.
- Frequently observe jobs in progress to ensure adherence to the radiological protection rules, regulations, procedures and Tetra Tech FW radiological protection program and recommend changes to the radiation protection program as needed to reduce radiation exposure.
- Responsible for the direction and supervision of the technicians, subcontractors, laborers, and daily operations.

### 3.1.2 Radiation Safety Office (RSO) or Site Health and Safety Specialist (SHSS)

The RSO or the SHSS in the absence of the RSO has primary responsibility for the adequacy of site radiation protection measures and ALARA (As Low As Reasonably Achievable) programs, and for ensuring compliance with radiation protection rules, regulations, and procedures. The RSO (or designee) will be assigned the following specific responsibilities:

- Implement and maintain the site radiation program including applicable plans and procedures.
- Monitor and evaluate the radiological status of the project and the site.
- Make recommendations for the control and elimination of existing and potential radiological hazards.
- Issue dosimetry devices and ensure adequate exposure monitoring procedures are in place for project activities.
- Function in an advisory capacity to assist personnel in carrying out their radiation protection responsibilities.
- Stop work if conditions indicate that a potential for an unanticipated excessive radiation exposure to personnel or the general public exists or an individual violates the radiation protection rules, regulations or procedures which may adversely affect personnel working at the site or the general public.
- Ensure that radiation exposures are ALARA.
- Assist in providing required reports of personnel exposures to individuals and to applicable regulatory agencies in cooperation with the Director, Health Physics Programs, Tetra Tech FW Corporation.
- Implement and maintain records of radiological surveys and evaluations.
- Ensure adequate radiation safety training is provided to all project personnel and maintain documentation.
- Prepare, implement, and maintain a radiological respiratory protection program, as necessary.
- Arrange, as required, all necessary services for bioassay analysis.

- Arrange maintenance and calibration service and maintain associated records for radiation survey instruments used at the site.
- Ensure that all required monitoring is performed at the site.
- Ensure that occupational monitoring is provided for workers who may come in contact with radiologically contaminated material.
- Perform periodic safety and quality reviews and monitor activities of project operations to ensure compliance with this plan.
- Review planned site activities and implement safety procedure to ensure safe performance and completion of the work.

### 3.1.3 Radiological Controls Technician

Tetra Tech FW Corporation will provide radiological controls technicians (RCT) to implement the health physics monitoring and surveys required by regulations, Tetra Tech FW Corporation's programs; and this plan.. The RCT will:

- Implement the radiation protection program under the direction of the SHSS, the PESM, and the Director, Health Physics Programs.
- Perform and interpret, in consultation with the PESM and/or the Director, Health Physics Programs, all required monitoring and surveys.
- Implement and enforce radiological protection requirements under his/her control.
- Stop work when necessary to maintain a safe radiological and industrial work area.

### 3.1.4 Individuals

Each individual is responsible for demonstrating familiarity with the radiation protection program, for strict adherence to the radiation protection rules and regulations, and for minimizing radiation exposure to the maximum extent possible. Flagrant or willful disregard of radiological protection rules, regulations, or practices may result in disciplinary action. Individual's basic responsibilities are:

- All individuals working in any restricted area will have a working knowledge of site radiological protection rules, regulations and procedures. This will be accomplished by training and instruction commensurate with the individual's work assignment.
- Individuals shall know the specifics of the task or job that they are to perform. This should be accomplished through the use drawings, diagrams, plans, technical manuals, standard operating procedures, or instructions from supervisory personnel.
- Individuals will understand and follow the radiological protection requirements. Individuals should acquaint themselves with the radiological status of the areas they are assigned to work in.
- Individuals will discontinue work on a job or task whenever problems arise that may adversely affect the overall radiation exposure received from the job or the radiological status of the job. The individual will notify the RSO to reassess the situation.
- Individual workers are not expected to be experts in radiological controls, consequently, radiological controls supervisor personnel (e.g the RCT and/or the RSO) will always be available while work in affected areas is in progress. Individuals will follow directions of the RCT and/or the RSO to the maximum extent possible.
- Individuals are required by federal regulations to report promptly to management any condition that may lead to or cause a violation of the radiation protection rules or regulations or unnecessary exposure to

radioactive materials. Individuals will make these reports to their immediate supervisor, health physics personnel, the RSO and/or SHSS or the PESM.

3.1.5 Director, Health Physics Programs

The Director, Health Physics Programs (CHP) or designee will advise the PESM and the RSO and/or the SHSS as necessary to ensure the radiological and technical aspects of the project meet all federal and state standards. The CHP will:

- Make recommendations to the PESM, the RSO and SHSS for the control and elimination of existing and potential radiological hazards.
- Function in an advisory capacity to assist personnel in carrying out their radiation protection responsibilities.
- Request that work stop if conditions indicate that a potential for unanticipated excessive radiation exposure to site personnel or the general public exists or if an individual violates the radiation protection rules, regulations, or procedures which may adversely affect personnel working at the site or the general public.
- Assist in training of individuals in the biological effects of radiation as needed.
- Coordinate and assist the PESM on the oversight of any bioassay and dosimetry program to ensure proper monitoring of internal and external exposures.

4.0 ALARA

ALARA means "As Low As Reasonably Achievable". It is Tetra Tech FW's policy to maintain radiation exposures to its employee, subcontractors, and the general public as far below the limits specified by federal law as is reasonably achievable. The ALARA program is implemented through the training of employees and subcontractors, by work procedures and site control, good housekeeping practices, and as necessary, use of personal protective equipment.

5.0 External Exposure to Radiation

5.1 Requirements

Tetra Tech FW Health Physics Programs have been developed and are directed by a Certified Health Physicist (CHP) who serves as the Director, Health Physics Programs. Consistent with the commitment to ALARA, administrative control limits are established at levels below regulatory limits to prevent inadvertent overexposure, and to serve as an action level and control point to establish a radiation exposure that should be investigated. The administrative exposure limit for the project is established at a Total Effective Dose Equivalent (TEDE) of 0.05 rem for the entire project. If an individual receives an exposure that exceeds an administrative limit, an investigation will be conducted to determine the cause of such exposure and to determine if future exposures can be avoided.

5.2 Exposure Control

The basic methods used to control radiation exposure include training, personnel monitoring, evaluation of radiological conditions, use of work instructions and site control procedures, posting areas, implementing engineering controls, and specifying/using personal protective equipment.

5.2.1 Personnel Monitoring and Dosimetry

The RSO is responsible for ensuring that all site personnel are appropriately monitored for exposure to ionizing radiation. If after site assessment, it is determined by the CHP that dosimetry is required, the RSO will ensure that all individuals will wear dosimetry devices specified by the CHP. Visitors will not wear dosimeters as they will not be allowed to enter a controlled area. The wearing of dosimetry devices will be managed in accordance with Tetra Tech FW Health Physics Programs as specified by the CHP.

### 5.2.2 Personnel Exposure Investigations

If a situation occurs where there is suspected or known exposure of personnel in excess of the TEDE, the incident will be reported immediately to the SHSS who will notify the PESM. Evaluation will be made by the PESM in consultation with the CHP.

### 5.2.3 Site Control

Since radiation hazards, once discovered by screening methods, are hazards in addition to the other chemical hazards at the site, an enhanced site control program will be established at such time. This program will require that all personnel leaving the work area are "frisked" for radioactive contamination prior to leaving the controlled zone (exclusion zone). Additional requirements will be established once these hazards are identified.

## 6.0 Internal Exposure to Radiation

## 6.1 Requirements

Tetra Tech FW Health Physics Programs have been developed and are directed by a Certified Health Physicist (CHP) who serves as the Director, Health Physics Programs.

### 6.1.1 Federal Regulations

Internal radiation exposure must be maintained within the limits specified for Derived Air Concentration (DAC) for radioactive materials in air for the controlled (restricted ) areas and the non-controlled areas (unrestricted). Refer to 10 CFR 20, Table 1, Appendix B.

### 6.1.2 Administrative Control Limits

Consistent with the project's commitment to ALARA, administrative control limits are established to prevent inadvertent overexposure, and to serve as an action level to establish when engineering and administrative controls, and personal protective measures are implemented. Administrative control limit for airborne concentration of radioactive materials is set at 10% of the applicable DAC value. Areas that exceed the control limits will be posted as an Airborne Radioactivity Area. Engineering and/or administrative controls will be implemented, as practical, to reduce the airborne concentrations of radioactive materials below the control limits. When such controls are not feasible or ineffective in reducing the concentrations below the control limits, respiratory protection equipment will be used.

### 6.1.3 Bioassay Samples

The Director, Health Physics Programs will determine if bioassays of workers is required prior to the start of any work, once a survey or screening procedure has identified the presence of radioactive materials.

## 6.2 Respiratory Protection

To minimize the potential for an internal uptake of radioactive material, respiratory protection will be evaluated and provided as needed. When needed, air sampling and required respiratory protection will be provided as specified by the PESM. Full-face air purifying respirators with P100 (HEPA) cartridges will be the first choice for personnel protection in areas with high airborne radioactivity. If air samples, indicate airborne contamination levels are too high for the use of air purifying respirators, all work will stop until other methods are developed to control airborne concentrations of radioactive materials.

## 7.0 Controlled Access Areas

Controlled access areas are established for the purpose of controlling radiation exposures to all workers, visitors and the general public.

### 7.1 Definitions

- Controlled Access Area – an area to which entry is regulated to prevent unnecessary radiation exposure.
- Radiologically Controlled Area - an area which requires health physics monitoring and dosimetry. This area will be fenced or roped off and will be posted. The area will include any exposed excavation which has the potential of containing radioactive material or which is known to have contained a radiological anomaly based on site surveys. Site support equipment will be segregated from the controlled are to limit workers exposure from the radiation areas.
- Clean Area – an area where radioactive material is not present in quantities large enough to warrant radiation protection practices. Areas outside the restricted area are considered "clean areas." In addition, certain areas within the controlled area may be temporarily designated as "clean areas". The site support area is a clean area.
- Radiation Area – an area, accessible to individuals, where radiation levels could cause an individual to receive a dose equivalent in excess of 0.005 rem in 1 hour at 30 cm from the radiation source or from any surface which the radiation penetrates.
- Airborne Radioactivity Area – an area posted as such if the concentration of airborne radioactive materials exceeds 10% of the DAC.
- Radioactive Material Storage Area – an area or room designated for storage of contaminated or potentially contaminated radioactive material. The area must be posted.

### 7.2 Controlled Access Area Entry Requirements

All personnel entering the controlled access area will have received training in radiation safety or will be escorted by personnel that have received the training. All individuals entering the controlled access area will read and sign the Site-Specific Health and Safety Plan acknowledging their understanding and adherence to the requirements set forth in that document. There shall be no eating, drinking, smoking, or chewing allowed within the area except in designated "clean areas." The need for respiratory protection will be evaluated and documented for all personnel entering an Airborne Radioactivity Area.

All personnel and equipment/material leaving the restricted area will be surveyed for radioactive contamination prior to exiting the area.

### 7.3 Clean Area Requirements

Clean areas will be surveyed for radioactive surface contamination at a minimum of once per week. Clean areas will be promptly decontaminated if surface contamination levels exceed the values specified for the project.

## 8.0 Training Requirements

Training is one of the most important elements in an effective radiation protection and ALARA program. The amount and type of training depends upon the individual's work assignment.

### 8.1 Regulatory Requirements

10 CFR 20, 29 CFR 1910.96, and 8 CCR Article 102 require that training be given to radiation workers.

### 8.2 Training

#### 8.2.1 All Workers

All workers will receive the following training:

- Fundamentals of Health Protection
  - The radiological and toxic hazards of exposure to radioactive materials
  - How radioactive materials enter the body
  - Why exposures to radioactive materials should be kept as low as reasonably achievable (ALARA)
- Personal Hygiene on Site
  - Wearing protective clothing
  - Using respirators
  - Eating, drinking, smoking, and chewing only in designated "clean" areas.
  - Using proper methods for decontamination
- Site Specific Control Systems
  - Standard operating procedures
  - Site control procedures
  - Security and access control to designated areas
  - Hazards specific to this site
- Health Physics Protection Measurements
  - Measurements of airborne radioactive materials
  - Possible bioassays to detect radioactive materials
  - Surveys to detect contamination of personnel and equipment
  - Personnel dosimetry and dose limits
- Radiation Protection Regulations
  - Employee rights
  - Radiation protection requirements in the DOE radiological Controls Manual
  - Fertile female and fetal protection.
- Emergency Procedures
  - Personnel injury
  - Fire
  - Site Evacuation

- Site-Specific Health and Safety Plan emergency procedures.

8.2.2 Training for SHSS and Radiological Control Technician (RCT)

The SHSS and the RCT will have attended a course of instruction of at least 8 hours in duration which contains a basic review of radiation, a discussion on the units used for measuring radiation, radiological concerns, radiation protection and risk assessment, operation of radiation measuring instruments, obtaining survey samples and data, regulatory compliance, handling radioactive materials and check sources, and managing a radiation safety program. This training must meet training as recommended or specified by the Director, Health Physics Programs.

9.0 Calibration of Equipment

Refer to Tetra Tech FW Radiological Protection Program RP3-37 "Portable Radiation Detection Instrumentation Operational Checks."

10.0 Records and Reports

Refer to the specific Tetra Tech FW Radiological Protection Programs referred to in this plan for the type of documentation and reports that must be prepared.

11.0 Radiological Controls

Potential radiological hazards associated with the performance of the project and exposure pathways include the following:

11.1 External Exposure to Gamma and Beta Radiation
Thin layers of material readily stop beta particles. Protective clothing is useful in reducing exposure to extremely low levels. Beta radiation, although more penetrating than alpha, is stopped by protective clothing or within the outer dead skin layers. Beta radiation protection for the eyes and sensitive areas should be used to minimize internal exposure. Gamma radiation will penetrate significant thicknesses of material; therefore, protective clothing is of little value in the reduction of external gamma radiation exposure. Methods of reducing exposure to gamma radiation include minimizing time spent in close proximity to the material, maintaining sufficient distance from any significant sources, and introducing shielding materials between sources and personnel. For the work activities to be performed and the levels of materials that may be present at the project site, the potential hazards associated with external exposures to radiation are minimal.

11.2 Internal Exposure to Alpha particle Radiation Through Inhalation
Interior and exterior surfaces of equipment may become contaminated with removable, dispersible contamination, introducing the possibility of internal exposure to the radionuclides. Appropriate engineering controls, administrative management controls, and respiratory protective equipment will be used as necessary during specific activities to reduce potential inhalation or ingestion by workers. Selection of appropriate protective measures is based on results of surveys and sampling prior to and during work activities. Airborne radioactivity will be monitored on a daily basis during operations. The monitoring will use a low-volume perimeter air sampler, if required by the PESM.

11.3 Internal Exposure to Alpha Particle Radiation Through Ingestion

Airborne or surface contamination may be transferred to the mouth of an individual by breathing or direct physical contact and the material ingested. Methods of minimizing internal exposures via ingestion include conducting contamination measurements when leaving potentially contaminated areas, maintaining good work practices and good hygiene during the project, prohibiting acts with increased likelihood of ingestion and wearing appropriate personal protective equipment.

## 12.0 Radiological Monitoring and Sampling

At the beginning of the project, a radiation survey of the work area will be performed as described in Tetra Tech FW Radiological Protection Program RP3-32 "Radiation Surveys". During the course of the project, a radiation survey of clean support areas will be performed at least once each week using the same procedure. Contamination surveys will be performed as described in Tetra Tech FW Radiological Protection Program RP3-33 "Contamination Surveys." A contamination survey will be performed daily at the access control point to assess the adequacy of contamination control. Also a daily contamination survey will be conducted in the controlled work areas. Personnel contamination monitoring will be performed when personnel exit a controlled area. Perimeter air monitoring will be performed using dust samples collected by a low-volume air sampler. The samples will be analyzed using the instrumentation selected for this project.

### 12.1 Radiological Instrumentation

Refer to the Radiological Survey Procedures for selection of instrumentation. Also refer to RP3-37 which has been discussed previously. Check source will be kept in a locked container and managed as described in Tetra Tech FW Radiological Protection Program RP3-36 "Shipment and Transporting of Radiological Instrument Check Sources."

## 13.0 Decontamination

Should equipment or personnel become contaminated with radionuclides, the equipment or personnel must be decontaminated. Measurements of contaminant should not be averaged over more than one square meter. For objects of less surface area, the average should be derived for each object.

### 13.1 Equipment

Equipment or materials that are contaminated in excess of release limits established by the CHP will be decontaminated using such methods as washing with soap and water, or removing tape (if used) before removal from work area. Storing equipment in a relatively uncontaminated area and allowing radioactive decay to reduce the contamination levels is an acceptable procedure for short-lived decay products. If any contamination is detected, decontamination measures will be implemented again.

### 13.2 Personnel

Personnel "frisking will be performed as described in RP3-33 referenced previously. The release limits for personnel will not exceed 100 counts per minute above background for beta/gamma using the Eberline HP260 probe. When personnel exit a controlled area, they will remove any protective clothing and place clothing in the designated disposal container. The RCT will perform an exit survey of the whole person using a step-off pad as necessary. Personnel who still have levels above this level will perform further decontamination to

include brushing or washing of boots, hand/or face washing and potentially complete body washing prior to exiting the site.

### 13.3 Disposal of Wastes

Wastes will be handled and stored separately from other wastes that have no measurable radioactivity. The waste containers will be labeled and stored in an area designated by the RPM.

## 14.0 Anomaly Removal Packaging

All radiological anomalies removed from the excavation area will be surveyed for radiation and contamination and will be packaged in metal drums for future disposal. These containers will be sealed, surveyed, and labeled prior to placing them in a designated radioactive material storage area.

## ATTACHMENTS

1. Radiological Survey Procedures and Remediation of Radioactive Point Sources
2 Tetra Tech FW Radiological Protection Program Procedures

# RADIOLOGICAL SURVEY PROCEDURES
# AND
# REMEDIATION OF RADIOACTIVE POINT SOURCES

## 1.1 IN-SITU RADIOLOGICAL SURFACE SURVEY

The purpose of the in-situ radiological surface survey is to identify and locate surface and near-surface (i.e., less than 12 inches bgs) radioactive anomalies for subsequent removal and off-site disposal.

The in-situ surface survey will be a high-density survey performed using radiation detection equipment utilizing gamma detectors. Typical system configuration consists of four 3-inch by 3-inch shielded NaI(Tl) detectors (or equivalent) mounted abreast on a cart so that the detection surface is approximately 3 inches from the surface of the ground, depending on the terrain being surveyed. This arrangement is capable of surveying a path that is approximately three feet wide, typically providing reliable survey data up to a depth of approximately 12 inches. When ground coverings such as gravel and asphalt are present, the effectiveness of the detection equipment is reduced; however, radioactive anomalies can still be detected if they are located relatively close to the surface. This limitation is not considered significant because asphalt and/or gravel on the surface is not expected in this area.

The high-density survey process will result in a 100 percent scan survey when the terrain is reasonably smooth and clear of obstructions. For terrain that is not smooth but is accessible to personnel, the radiation survey can be performed utilizing a handheld 2-inch by 2-inch NaI(Tl) detector. Data analysis will be performed as it is received and questionable areas will be flagged in the field for re-survey/verification. Locations where surface radiation levels are greater than 1.5 times the background will be noted on a grid map. Handheld equipment will be used for verification of the anomalies. Areas confirmed as containing radiation levels greater than the 1.5 times the "mean" background level established for the site will be physically marked and the associated anomalies removed as described in below.

Details on the instruments that may be utilized for the radiological screening are presented in Section 1.9.

## 1.2 REMOVAL OF RADIOACTIVE CONTAMINATED MATERIALS

Each radioactive anomaly identified by the site data processing team during the in-situ surface survey will be investigated and associated point sources and/or contaminated soil/debris will be removed. The area within a radius of 5 feet around (10-foot diameter) of the target anomalies will be searched using a 2-inch by 2-inch NaI(Tl) scintillation probe coupled to a survey meter (or equivalent) to identify the specific location of each anomaly. Each location with an elevated radiation level will then be excavated, and radioactive contaminants will be removed as discussed in this section.

A small backhoe fitted with a smooth blade bucket and/or hand-digging tools will be used to excavate areas with radioactive anomalies identified during the in-situ radiation survey. Soil in an area centered on each anomaly will be excavated using the field instruments to guide the soil removal. The excavated soil will be spread on a 20-mil polyvinyl chloride (PVC) liner adjacent to the excavation and will be surveyed with a 2-inch by 2-inch NaI(Tl) scintillation probe

coupled to a survey meter (or equivalent) positioned 4 to 6 inches above the soil surface. The instruments may be fitted to a wheel and arm device capable of supporting the detector at the desired height. Soil removal will continue until the source of the high gamma activity reading is discovered and removed.

Following removal of each source of the elevated gamma activity reading, an additional 1-foot of soil in all directions of the source will also be removed. When the point source and surrounding soil are removed, the resulting pit will be re-scanned for radiation using the handheld detector. If gamma radiation levels above 1.5 times background levels persist after identifiable point source items are removed, further examination of the soil will be made until the source of the high gamma radiation activity is found.

The soil excavated in each anomaly area and spread over the 20-mil PVC liner adjacent to the excavation will also be surveyed for radiation. Excavated soil with a gamma radiation count exceeding 1.5 times background will be placed in a B-25 container box for further testing, characterization, and disposal. Soil with gamma radiation counts that are equal to or less than 1.5 times background will be placed in a separate stockpile for subsequent reuse as backfill material or disposal. The radiological point sources (such as radium-containing dials) recovered from each pit will be packaged in metal drums in accordance with Department of Transportation (DOT) regulations specified in 49 CFR Subpart I, and will be stored in a designated and posted radioactive material storage area for subsequent disposal. Additional details on management of radiological point source wastes are also discussed below.

Details on the instruments that may be utilized for the radiological screening are presented in Section 1.9.

## 1.3 SOIL EXCAVATION AND REMOVAL OF ADDITIONAL RADIOACTIVE-CONTAMINATED MATERIALS

At the conclusion of the in-situ surface survey and subsequent removal of point sources and radiation-impacted soil/debris, the radiological removal of the site will be complete. However, radiological contamination may extend deeper than 1 foot bgs in some areas based on previous assays. Therefore, additional soil excavation will be required in those previous assayed areas to expose, locate, and remove this contamination.

After each of the anomalies in the upper 12 inches of soil have been located and removed, an excavator will be used to remove the remaining soil in the top 12-inch-thick layer of soil within site.. Large-size debris will be segregated from soil during excavation. As required, a water truck equipped with a hose will be used to mist the soil and debris during excavation and segregation to minimize the potential for release of airborne contamination.

Both the debris and the excavated soil will be placed in dump trucks and hauled to a screening pad constructed as described in Section later in this procedure. At the screening pad, a second ex-situ radiological survey of the material will be performed to identify radiologically contaminated materials that may not have been detected during the in-situ surface survey. To perform the ex-situ survey on the soil, it will be spread across the screening pad in a 6- to 8-inch layer and then surveyed using the hand-held, backpack, or cart mounted NaI(Tl) scintillation detectors attached to a portable count rate meter (or equivalent).

Debris that will be surveyed at the screening pad may include tree roots, vegetation from previous grubbing and clearing activities, asphalt, concrete, wood, lumber, wood poles, piping,

tires, metal objects, plastic, glass or similar waste material. Because it is possible that the debris may contain discrete radioactive sources (for example, radioactive instrument dials), to prevent potentially radioactive materials from leaving the site, the debris will be surveyed for radioactive-containing material using handheld NaI(Tl) scintillation detectors attached to a portable count rate meter (or equivalent).
Radiologically contaminated soil or debris exhibiting gamma radiation activity above 1.5 times background that is identified during the ex-situ survey will be segregated as low-level radiation waste and placed into B-25 boxes. Discrete radioactive sources will be collected and placed in Ziploc® plastic bags and segregated from the soil and large debris to facilitate their disposal.

Soils that do not exhibit radiological activity greater then 1.5 times background will be placed in a soil stockpile constructed pending subsequent disposal or replacement in the excavation. Large debris that is not suitable for replacing within the excavation and that has been cleared of radioactive-containing material will be placed in rolloff bins that may be temporarily stored onsite pending transport to a CERCLA Offsite Rule-approved landfill for disposal.
After the first 12inches of soil and debris have been excavated, screened, and stockpiled/properly contained, an in-situ surface survey of the excavation floor will be performed.. This survey will be used to locate and identify radiological anomalies in the 1- to 2-foot bgs soil interval in other excavations. Each anomaly identified by this in-situ scan will be investigated and addressed using the same procedures outlined.. When each anomaly has been addressed, the 1- to 2-foot bgs soil interval will be excavated from the each excavation. The excavation and subsequent screening and waste management of the soil and debris within this interval will be conducted in accordance with the procedures described in this section.
Additional iterative repetitions of in-situ screening, anomaly investigation and removal, and soil excavation will be completed until the excavation is determined to not contain radioactive material or groundwater is encountered whichever is sooner.

### 1.3.1 Screening Pad

A 75-foot by 100-foot pad for the spreading and radiation screening of excavated soils and debris will be constructed on the project site. The soil and debris screening pad will be constructed of two 20-mil layers of high density polyethylene (HDPE) liner. Prior to constructing the screening pad, the pad area will be cleared of rocks, debris and other items that could puncture the lower HDPE liner. The first layer of the HDPE liner will then be placed directly on the ground surface. A 6-inch layer of coarse sand will then be placed over the first layer of the 20-mil HDPE liner. A second layer of 20-mil HDPE liner will then be placed over the coarse sand layer. The purpose of this design is to prevent puncture of the layers, thereby preventing any contaminated soil or leachate from coming in contact with the native soil. The screening pad will be bermed with sandbags. Sumps will be installed to collect any water that may leach out from the contaminated soil spread over the pad. A temporary storage tank with appropriate secondary containment will be used to collect any leachate that accumulates in the screening pad sump. Any soil and debris that is staged on the pad overnight will be covered to minimize the spread of contamination.

### 1.3.2 Soil Stockpile

Excavated soil will be placed on a 120-foot-wide by 150-foot-long stockpile containment pad constructed of two layers of 20-mil-thick HDPE liner similar to the screening and sifting pad, except that the coarse sand layer will be 3 inches thick. Prior to construction, the stockpile the area will be cleared of rocks, debris and other items that could puncture the lower HDPE liner. The stockpile pad will be constructed adjacent to the screening and sifting pad. In accordance with the SWPPP, the stockpile area will be bermed with clean soil or sandbags to prevent surface water runoff or rainwater from coming into contact with the stockpiled material in accordance with the RCRA staging pile regulations of 40 CFR, Part 264.554, and Section 25123.3 of the California Health and Safety Code provision for stockpiling of non-RCRA hazardous soil. A 6- to 8-inch-high berm will be constructed surrounding the stockpile area. The 20-mil HDPE liner will be extended over the berm surrounding the stockpile pad. In addition, to prevent rain from coming into contact with the stockpiled soil and to minimize wind dispersion of particulate matter, the stockpiles will be covered with a 10-mil liner and secured with sandbags at the end of each workday.

## 1.4 WASTE MANAGEMENT FOR RADIOLOGICAL DEVICES

The following subsections address specific control and management practices for discrete radiological point source items.

### 1.4.1 Packaging and Storage of Radiological Materials

All discrete radiological sources will be placed in metal drums and packaged in accordance with DOT regulations specified in 49 CFR Subpart I, following final verification of radionuclide content of the material by gamma spectroscopy. Soil with gamma radiation count exceeding 1.5 times the background gamma radiation count will be placed in B-25 boxes. The contents of each B-25 box will be recorded in the field logbook, and each B-25 box will be assigned a unique identification number.

The B-25 containers and the metal drums containing radium-containing devices will be stored in a designated and posted radioactive material storage area. This area will be designated.. All boxes and containers will be surveyed and surface radiation measurements will be collected using a Victoreen 450P ion chamber survey meter or equivalent. Prior to their transportation off-site for disposal, metal drums and all B-25 boxes will be surveyed and surface radiation measurements will be collected using a Victoreen 450P ion chamber survey meter or equivalent detector. Radiation survey of the boxes will also include taking smear samples to assess removable contamination. The smears will be subjected to at least a 1-minute count with the Ludlum 2929 Dual Range Scaler or equivalent system. Any removable alpha contamination in excess of the site free release limits of 20 disintegrations per minute (dpm) and the beta-gamma radiation exceeding 500 dpm release limit will be recorded on a log. The box will then be decontaminated and resurveyed.

### 1.4.2 Labeling and Posting of Drums Containing Radiological Waste

Each metal drum containing radiological waste will be labeled with an appropriate DOT label. Transportation indices will be determined for each drum. The radioactivity contained in each metal drum and maximum contact radiation levels will be measured in mR/hr. Following the surveying and labeling, the metal drums will be placed on a pallet in a designated and posted

radioactive materials storage area and covered with plastic sheeting. The covered metal drums will be posted with a "Caution – Radioactive Materials" sign. The sign will also note the maximum surface radiation level (measured in mR/hr).

### 1.4.3 Collection and Identification of Radiological Devices

Point sources may include radium-containing devices such as radioluminescent dials, markers, clocks, and other instruments. The sources will be placed in Ziploc® plastic bags, and labeled with the grid number and hole number where they were found. Each bag will be electronically photographed and the radiation level measured using a MicroR meter or equivalent survey instrument. A master inventory list will be constructed which will include: (1) the date of collection, (2) grid identification, (3) point source description, (4) radiation level, and (5) the electronic photo.

### 1.4.4 Radiological Device Classification

Recovered point sources are expected to be grouped into one of the following three classifications:

1. Identifiable intact manufactured items
2. Debris or pieces from manufactured items, including rusted, corroded, or soil encrusted items, and in some instances, flakes of actual phosphor material from dial or gauge faces
3. Soil or soil-like objects or material

### 1.4.5 Gamma Radiation Measurements and Activity Assessment

Gamma radiation measurements will be conducted for each point source or Ziploc® plastic bag containing point-source materials. Previous site investigations have identified Ra-226 as the primary radionuclide of interest. The dose rate at 1 meter for 1 milliCurie (mCi) of Ra-226 in equilibrium with its decay products is listed as 0.84 mR/hr per mCi. The radioactivity of each point source will be estimated by noting the radiation level at a specific distance from the point source and by adjusting for the actual measurement distance by means of the inverse square law. A standard measurement distance of 10 cm (4 inches) will be used. From inverse square considerations, the resultant dose at 10 cm per μCi of Ra-226 would be:

$$\text{Dose rate}/\mu\text{Ci} = 0.00084\ \text{mR}/\mu\text{Ci} \times (100/10)^2$$

$$= 0.084\ \text{mR/hr}/\mu\text{Ci}$$

Dose rate measurements will be taken with the Technical Associates TBM-15 GM survey meter with the beta shield in place or with the Victoreen 450P ion chamber, or equivalent instruments. In both cases, source to detector geometry will be taken into consideration when interpreting the resultant measurement. For small point sources, the geometry will be verified experimentally by noting the instrument response when exposed to a 1 μCi cesium-137 check source. For larger, volumetric sources, radiation measurement will be adjusted for extended source and self-absorption factors.

### 1.4.6 Offsite Gamma Spectroscopy

Offsite gamma spectroscopy will be performed to confirm radionuclide identity and measure waste activity to support packaging of discrete radiological sources for disposal. Gamma

spectroscopy will be conducted using a 3-inch by 3-inch NaI(Tl) scintillation spectrometer connected to a Princeton Gamma Tech QCC Multi-channel Analyzer, or similar gamma spectroscopy system. The energy range of 0 to 3.0 million-electron volt (meV) will be selected for isotope identification.

## 1.5 CONFIRMATION TESTING OF THE EXCAVATION

After the excavation is complete, verification sampling will be performed to confirm that the radioactive-contaminated material has been removed and that the cleanup goal of less than 2 pCi/g for Ra-226 and the cleanup goals for other radionuclides of interest, if any, are achieved. For consistency, verification sampling will be conducted after establishing a 30-foot by 30-foot grid along the excavation bottom (including sloped sidewalls). One sample will be collected at a randomly located point within each grid cell. These samples will be subjected to radiochemical analysis at a Navy-approved, State-certified laboratory to identify the types and activities of each radionuclides present in the sample. This verification sampling will use EPA Test Method 901.1 and will be conducted in accordance with MARSSIM guidance.

## 1.6 BACKFILL PLACEMENT AND SITE RESTORATION

After verification sampling has been conducted, a land survey of the excavation will be performed. This information will be used to locate the verification samples, assess the volume of material excavated, assess the excavation contours, and assess whether any additional backfill material will be required.

Excavated soil that did not contain radiation in excess of 1.5 times background will be used to backfill the lower portion of the excavation. However, prior to placing this material back into the excavation, samples will be collected from the stockpiled soil. These samples will be subjected to radiochemical analysis at a Navy-approved, State-certified laboratory to verify that radiological contaminants in excess of the cleanup criteria are not placed back into the excavation.

The upper limit for using excavated soil to backfill the excavation is 3 feet bgs. From 0 to 3 feet bgs, clean imported fill material will be used to provide a buffer between the ground surface and soil placed back in the excavation that may still contain chemical contaminants. Imported soil will be considered acceptable for use to backfill the upper portion of the excavation if it meets the following criteria:

- Organic chemical compounds are not present at concentrations above EPA industrial Preliminary Remediation Goals (PRGs), or base-specific concentrations for TPH.
- Metals concentrations are not present above HPALs or EPA industrial PRGs, whichever is greater.

Prior to placing imported fill material in the excavation, it will be tested to certify that it meets these criteria. Import fill testing requirements are discussed in the SAP.

Backfill will be placed in the excavation in 12-inch lifts. Where possible, the backfill material will be compacted to approximately 90 percent of the maximum dry density using a roller compactor, or equivalent. The final 6 inches of backfill will not be compacted, but will be graded to match its surrounding elevation for site restoration. The DON may elect to let the surrounding plants naturally take over the area to simplify the management of vegetation at the site.

## 1.7 SITE AMBIENT GAMMA RADIATION LEVEL SURVEY

A survey of the site ambient gamma radiation levels by grid number will be conducted at completion of the removal action and backfill of excavated areas. The purpose of the survey will be to document any differences between the post-remediation ambient gamma radiation levels and general area background levels.

The survey will be conducted using the Victoreen 450P ion chamber survey meter or equivalent survey meter. At the start of each survey session, the 450P instrument will be turned on, functional checks will be performed, and the instrument will be allowed to stabilize for 5 minutes. (The 450P instrument has a digital liquid crystal readout display, which has a tendency to cycle from one value to another.)

The site area will be divided into 100-foot by 100-foot square grids, and each grid will be surveyed for ambient gamma radiation levels. A measurement will be taken at the center of each grid, approximately 39 inches (1 meter) above the soil surface. Some variation in the height above the surface may occur because of unevenness of the terrain in certain parts of the site. Several seconds (up to 1 minute) per reading will be required to ensure repeatability of the measurement before the value is recorded. At dose rate ranges of 2 to 10 μR/hr, the instrument has a tendency to cycle between values before repeatable readings can be obtained. The final reading will be recorded in the radiological measurement log. Uncertainty in any reading will be assumed to be +/- 20 percent.

The results will be identified by grid letter and row number and will be documented in a log. The average site gamma radiation level will be calculated in μR/hr. Grids with radiation levels higher than background will be identified. The average net dose rate will be calculated using the background value that will be determined in accordance with Section 4.20.2. The average net dose rate will represent an average annual exposure of per year (in mR/yr), if someone were present 40 hours per week for 50 weeks per year.

## 1.8 FREE-RELEASE SURVEYS AND DECONTAMINATION PROCEDURES

As part of the demobilization activities free-release surveys will be conducted on all equipment, tools and storage areas prior to their demobilization and decommissioning. Free-release criteria of less than 20 dpm for removable alpha contamination and less than 500 dpm for beta-gamma removable contamination will be specified for the site. Surface radiation must be less that 1.5-times the established background levels.

Survey elements for excavators, dozers, and similar type heavy equipment will include surface scans and removable contamination smears taken at the cab interior, under-carriage, tracks, stick, and bucket interior and exterior. Survey elements for loaders and backhoes, and similar rubber tire equipment will include surface scans and removable contamination smears taken at all four tires, the front loader bucket interior and exterior, left and right hydraulic stabilization pads, the backhoe bucket interior and exterior, and cab interior. Hand tools used for radium-containing material removal will be surveyed for free release. Tools include shovels, pry bar, pick, broom, and similar items. If equipment survey results are below the site free-release criteria, the equipment will be released to the equipment rental vendor.

The instruments used for free-release surveys will be Bicron Surveyor alpha survey meter (or equivalent) and a Technical Associates TBM-15 beta-gamma GM survey meter (or equivalent). Smears will be taken and counted with the Ludlum 2929 Dual Range Scaler (or equivalent) for

1 minute. Survey details and measurement results will be recorded in a radiological release survey report and the radiological release log.

## 1.9 RADIOLOGICAL SURVEY AND SCREENING EQUIPMENT

Several types of instruments may be used to conduct the radiation surveys, provide analytical data, and monitor radiation control practices during project. The Ludlum 2360 data logger and 2-inch by 2-inch NaI(Tl) scintillation probe, or equivalent data logger/detector combination, will be the primary field survey instruments. Other portable field survey instruments (or their equivalents) that may be used in the field include the following:

- Ludlum Model 2221 w/SPA-3
- Ludlum Model 18, GM, proportional and scintillation detectors
- Ludlum Model 192 MicroR Meter
- Ludlum Model 9 Ion Chamber
- Ludlum Model 17 Ion Chamber
- Ludlum Model 2241-3 Digital Scaler/Ratemeter
- Ludlum Model 177 Alarm Rate Meter
- Ludlum Model 2360 Data Logger
- Ludlum Model 2350-1 Data Logger
- Ludlum Model 3030 Alpha/Beta Scaler
- Eberline E-600 and associated smart probes
- Eberline E-140
- Victoreen 190
- Technical Associates TBM-15 thin-window [1.5 to 2 mg/cm$^2$] GM detector
- Bicron Surveyor alpha scintillation survey meter
- Victoreen 450P Low Range ("microR") Ion Chamber Survey Meter

The following subsections address the calibration and background determination of selected pieces of equipment that may be used at the site. Equipment used at the site that is not discussed below will be calibrated and used in accordance with the manufacturer's specifications.

### 1.9.1 Calibration Verification

Prior to use of the radiation instruments, field calibration verifications and functional checks will be performed. The specific procedures will vary for each type of instrument and are discussed in the following sections.

**Ludlum 2221w/SPA-3 -** Background and source check calibration ranges will be established as the first step of the calibration process. Six readings (two sets of readings, three with a source

and three without a source) will be collected on scaler mode at 1-minute interval counts. The background and source check calibration ranges will be calculated as the average of each set of readings plus or minus 20 percent. The initial source check range will be determined using a uranium foil source located on the Victoreen 190 meter and later determined using a 1 microCurie (μCi) cesium-137 (Cs-137) point source, and the source check ranges for the uranium foil and the Cs-137 point source will be calculated and documented. Once the background and source check ranges are established, the instrument will be checked prior to each use to verify that the background and source checks are within the established ranges.

**Ludlum 3030 Dual Range Scaler** - Ludlum 3030 Dual Range Scaler system with a shielded Ludlum composite zinc sulfide scintillator optically coupled to a thin plastic scintillator allows simultaneous detection of alpha particles in the zinc sulfide scintillator and beta radiation detection in the plastic scintillator. The system can be used with a shielded sample holder that accommodate 1.75-inch diameter smears.

A functional check will be performed daily including background and thorium-230 (Th-230) and strontium-90 (Sr-90) reference source counts. The alpha channel function will be verified by taking five 1-minute counts with a Th-230 reference source. The average of the counts will be determined in dpm, and the counting efficiency and minimum detectable activity (MDA) will be calculated.

**Victoreen 190** - The Victoreen 190 Survey and Count Rate Meter is a portable instrument equipped with a model 489-110D GM probe. The probe is detachable and is fitted with a thin-window, 1.5 to 2 mg/cm$^2$, pancake GM tube. The instrument has a liquid crystal display with interchangeable scales calibrated for cpm or mR/hr with an operating range of 1 cpm to 1,000,000 cpm or 1 microroentgen per hour (μR/hr) to 1 Roentgen per hour (R/hr). A typical instrument background reading is 40 cpm. The instrument is not equipped with a beta shield, therefore it cannot be used to make gamma radiation dose rate measurements in the presence of alpha or beta radiation. The instrument will be used for field surveys including "frisking" of personnel and equipment, and field checks of smears. Prior to use, battery and functional checks will be performed.

**Victoreen 450P** - The Victoreen Model 450P is a pressurized ion chamber that is used for low-range, microroentgen, gamma radiation dose rate measurements. The instrument will be factory calibrated prior to use at the site. After calibration, it is designed to be self-checking for all critical functions at the time the instrument is initially turned on. The instrument requires 1 to 2 minutes to stabilize after it is turned on. Following stabilization, the instrument is ready to use.

**Bicron Surveyor** - The Bicron Surveyor instrument is a portable rate meter equipped with a thin-window zinc sulfide scintillator probe. The instrument is used for surface scans and field checks of smears taken from equipment and area surveys. Prior to use, battery and high voltage checks will be made to verify that battery and voltage values are within the acceptable range as indicated on the meter. Instrument background is typically zero.

**Eberline E-140** - The Eberline E-140 portable rate meter is equipped with a detachable thin-window (1.4 to 2 mg/cm$^2$) "pancake" GM probe. The instrument readout is calibrated only in cpm. The pancake probe is not equipped with a beta shield. The instrument will be used for field contamination checks of personnel, personal protective equipment (PPE), tools, and equipment. Instrument function will be verified daily, and includes battery, background, and reference source checks.

**Technical Associates TBM-15** - The Technical Associates Model TBM-15 is a portable rate meter calibrated in cpm and mR/hr. The TBM-15 has a detachable thin-window, 1.4 to 2 $mg/cm^2$, pancake probe. The instrument with the beta shield removed will be used for field contamination checks of personnel, PPE, tools, and equipment. The instrument can also used for surface scans (beta shield removed) and dose rate measurements including point source surveys. The beta shield will be kept in place for dose rate measurements. Instrument function will be verified daily and includes battery, background, and reference source checks.

### 1.9.2 Background Determination

Background will be determined as described in MARSSIM. Survey background levels are established by obtaining data points in an area having similar physical, chemical, geological, radiological and biological characteristics. When possible, the reference (background) area will be physically separated from the area of concern and located up-gradient or cross-gradient from the site area. By use of a histogram, which accounts for all of the data in the area, the "mean" radiation level will be determined. Based on this mean, a "background" radiation level will be established for the site.

### 1.9.3 Survey Equipment Background Determination

Radiological baseline surveys will be performed for each instrument to establish the normal background levels at the site. Background measurements will be generally performed at nearby unaffected areas.

**Ludlum 2221** - Ten background readings will be collected (five readings will be collected outside the site area, and five readings will be collected inside the site area, on a scaler mode at 1-minute interval counts. The site action level will be determined as the average of the ten readings multiplied by a factor of 1.5. The location where the background readings will be collected will be selected by the project health physicist.

**Ludlum 3030 Dual Range Scaler** - Background will be determined daily with a 10-minute count of a clean planchete. The results for the alpha and beta gamma channels will be recorded in the field logbook and on the daily scaler record sheet.

**Victoreen 190** - The background count rate will be observed following the daily instrument check and recorded in the field logbook.

**Victoreen 450P** - Initial background measurements will be taken at a location selected by the project health physicist. Ten readings will be taken and the average value will be calculated in μR/hr. Ten readings will be taken around the perimeter of the radium dials disposal area and the average value will be calculated in μR/hr.

**Bicron Surveyor** - The background count rate will be observed following the daily instrument functional check and recorded in the field logbook.

**Eberline GM Survey Meter** - The background count rate will be observed following the daily instrument check and recorded in the field logbook.

**Technical Associates TBM-15** - The background count rate will be observed following the daily instrument check and recorded in the field logbook.

# RP3-32 Radiation Surveys (Previously HSG1-10)

**Purpose**
To establish a standard method for performing radiation surveys.

| Date: 4/1/2000 – NEW |
|---|
| **Department/Category:** Administrative |
| **Document Type:** Procedure |
| **Keyword Index:** radiological protection, radiological monitoring, source check, radiation surveys |
| **Approved by:** |

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6.0 REFERENCES

- 6.1 Department of Energy
- 6.2 Nuclear Regulatory Commission
- 6.3 Other References

7.0 ATTACHMENTS

## 1.0 PURPOSE

To establish a standard method for performing radiation surveys.

## 2.0 SCOPE

This procedure addresses the surveying of personnel, equipment, materials and areas for radiation and contamination.

## 3.0 MAINTENANCE

The Director, Environmental, Health and Safety (EHS) Programs is responsible for updating this procedure. Approval authority rests with TTFW's President and Chief Executive Officer. Suggestions for revision will be submitted to both the department responsible for updating the procedure and the Director, Administration and Compliance.

## 4.0 DEFINITIONS

See RP1-2. Glossary of Radiological Protection Terms.

## 5.0 DISCUSSION

### 5.1 Responsibilities

#### 5.1.1 Project Health Physicist (PHP)

The PHP is assigned to a project by the Director, Health Physics Programs. The PHP provides project-specific health physics guidance on an as needed basis. Working with the Health and Safety Officer (HSO), the PHP conducts all required radiological safety training, reviews project field procedures, performs radiation safety oversight, and conducts radiation incident investigations.

#### 5.1.2 Environmental Safety Supervisor (ESS)

The ESS is responsible for implementing the Radiological Protection Program required by the project-specific HASP and the Radiation Protection series of procedures. The ESS maintains a project site file of radiological protection training, dosimetry records, radiological incident investigations, and other documentation pertinent to the Radiological Protection Program and

provides the files in accordance with RP2-8, Records, at the conclusion of the project. The ESS may serve as the PHP if he or she possesses the adequate criteria in the area of health physics.

## 5.2 Equipment

### 5.2.1 Personnel Protective Equipment

Personnel protective equipment and radiation dosimetry for the amounts and types of radiation expected as identified in the Health and Safety Plan or the Radiological Work Permit.

### 5.2.2 Radiological Instrumentation

The PHP will determine the appropriate radiological monitoring equipment for a given project. This decision will be based upon:

- Known or suspected radionuclides of concern;
- Type of ionizing radiation and energy range;
- Type of media the radionuclides exist in (e.g., water, soil, air, etc.); and
- Detection limits which must be met for the particular task.

As field data becomes available, the ESS is responsible to inform the PHP of the data. During the course of a field program the type of instrumentation may change depending on the field results. The PHP is responsible to understand the limitations that exist with each type of instrumentation.

Table 1 presents basic information on the type of detectors available and their limitations. The information presented in these tables is intended to provide general information on the specifications and applications of different instruments.

The specific operating instructions and procedures for each instrument should be read and understood before operating any instrument. The information presented below is intended as generic startup information.

Detection sensitivity for alpha or beta particles is reduced by the type of contaminated matrix (i.e., soil, asphalt, or concrete), matrix moisture content, layers of paint, vegetation, and other factors. These influences on the survey instrument sensitivity should be considered in planning the screening survey as well as interpreting the results.

It is mandatory that this procedure be used in conjunction with a site-specific Health & Safety Plan.

## 5.3 Preliminary Actions

### 5.3.1 Instrumentation Check

See RP3-37, Portable Radiation Detection Instrumentation Operational Checks.

### 5.3.2 Instrumentation Use

Select the proper window for the type of radiation to be monitored (if appropriate).

Observe the instrument as you enter a radiation field. Watch for dramatic fluctuations in the instrument response. Any questions related to the response of the instrument should be directed to the PHP.

Use the instrument in the manner for which it is calibrated.

During radiation surveys to set exposure rates, hold the dose rate instrument at 1 foot from the surface or source.

For ratemeter-type instruments with analog displays, allow 6-10 seconds for the instrument to stabilize and record the reading on the Survey Record Sheet in the appropriate units.

**Table 1 - Available Radiation Survey Instruments**

| Instrument | Radiation Detected | Typical Ranges | Remarks |
|---|---|---|---|
| GM Counters | β, γ | Low range:<br>0.2-20 mR/hr | Detection β > 150 keV<br>> 20 keV for x-rays<br>Rugged<br>Rapid response |
| | β, γ | High range:<br>To 10,000 R/hr | Strong energy dependence<br>Possible paralysis of response at high exposure rates<br>Sensitive to microwave fields<br>May be affected by ultraviolet light |
| Ionization Chambers | | | |
| Pressurized | β, γ and x | 0 - 0.5 to 0-5000 mR/hr | 10 μrem/hr sensitivity<br>Should be warmed up |
| Unsealed (Cutie Pie, RO-2, RO-3, RO-20) | β, γ and x | 0-5 mR/hr to 0-50 rem/hr | Typically have beta windows but beta correction factors are required |
| Pocket Ion Chamber (used as a pocket dosimeter) | x, γ | 0 – 200 mR | No warm-up<br>> 50 keV<br>Relatively inexpensive<br>Gives estimate of integrated dose<br>Small size<br>Subject to accidental discharge |
| Scintillation Counters | | | |
| Thermal Neutron | $n_{th}$ | 60 cpm per n $cm^{-2}$ $s^{-1}$ | ZnS (Ag) n-alpha reaction |
| Fast Neutron | $n_f$ | 15 cpm per n $cm^{-2}$ $s^{-1}$ | ZnS (Ag) proton<br>*ALL SCINTILLATION COUNTERS are sensitive to magnetic fields* |
| Neutron REM meters | | | |

| | | | |
|---|---|---|---|
| Bonner Sphere | $n_{th}$ - $n_f$ | 5-5000 mrem/hr | Cadmium leaded sphere plus $BF_3$ tube |
| Anderson-Braun | $n_{th}$ - $n_f$ | 2-2000 mrem/hr | $BF_3$ proportional counter Gamma insensitive to 500 R/hr |

Notify personnel in the area of survey results, with emphasis on changed or extraordinary conditions.

Record the results on a survey sheet, see attachment 1, or in a logbook, at the direction of the PHP. Include the date, time, instrument model, serial number, and surveyor's name in the logbook.

### 5.4 Records

Records of radiation surveys will be retained in accordance with RP2-8, Radiological Protection Records.

## 6.0 REFERENCES

### 6.1 Department of Energy

- DOE-STD-1098-99, Radiological Control

### 6.2 Nuclear Regulatory Commission

- NUREG-1507: "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions" (pre-published draft), Decmeber, 1997.

### 6.3 Other References

- Handbook of Health Physics and Radiological Health, 3rd Edition, 1998

## 7.0 ATTACHMENTS

Attachment 1 – TTFW Radiation/Contamination Survey Sheet

Attachment 2 – TTFW Radiation/Contamination Survey Map

Attachment 3 – TTFW Supplemental Radiation/Contamination Survey Sheet

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## Radiation/Contamination Survey Sheet

| SITE: | DATE: Yr Mo Day | TIME: | Page of |
|---|---|---|---|

| RWP # | CHARGE # | BLDG # |
|---|---|---|

SPECIFIC AREA OF SURVEY:

PURPOSE OF SURVEY:

### INSTRUMENT DATA

| Instrument Manufacturer(s) | Instrument Type(s) | Serial Number | Cal Due Date | Efficiency/CF |
|---|---|---|---|---|
| [] Bicron | [] ASP1 [] E120 [] E600 [] ESP1 | _____ | ___/___/___ | ___/___ |
| [] Eberline | [] HP260 [] Micro-Rem [] Model 3 | _____ | ___/___/___ | ___/___ |
| [] Ludlum | [] Model 16 [] RO-3C [] RSO-50E | _____ | ___/___/___ | ___/___ |
| [] _____ | [] SHP330 [] SHP340 [] SPA3 | _____ | ___/___/___ | ___/___ |
| [] _____ | [] _____ [] _____ | _____ | ___/___/___ | ___/___ |
| | [] _____ [] _____ | | | |

### RADIATION AND CONTAMINATION SURVEY RESULTS

Survey Map Attached: []Yes []No

| Sample Number | Description/Location | Total α (dpm/100 cm²) | Removable α (dpm/100 cm²) | Total βγ (dpm/100 cm²) | Removable βγ (dpm/100 cm²) | β mrad/hr | γ mrem/hr | Remarks |
|---|---|---|---|---|---|---|---|---|
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Remarks: Smears counted for _____/_____

SURVEYOR(S) NAME/ SIGNATURE/BADGE OR EMPLOYEE NUMBER _____/_____/_____

_____/_____/_____ _____/_____/_____

_____/_____/_____ _____/_____/_____

| Reviewed by: | Date: |
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## Radiation/Contamination Survey Map

| SITE: | DATE: Yr Mo Day | TIME: | Page of |
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| RWP # | CHARGE # | BLDG # |
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SPECIFIC AREA OF SURVEY:

PURPOSE OF SURVEY:

| Reviewed by: | Date: |
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| RWP # | CHARGE # | BLDG # |
|---|---|---|

SPECIFIC AREA OF SURVEY:

PURPOSE OF SURVEY:

### RADIATION AND CONTAMINATION SURVEY RESULTS

Survey Map Attached: []Yes []No

| Sample Number | Description/Location | Total α (dpm/100 cm²) | Removable α (dpm/100 cm²) | Total βγ (dpm/100 cm²) | Removable βγ (dpm/100 cm²) | β mrad/hr | γ mrem/hr | Remarks |
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Remarks: Smears counted for _____/_____

SURVEYOR(S) NAME/ SIGNATURE/BADGE OR EMPLOYEE NUMBER _____/_____/_____

_____/_____/_____ _____/_____/_____

_____/_____/_____ _____/_____/_____

Reviewed by: Date:

# RP3-33 Contamination Surveys (Previously HSG1-10)

**Purpose**
To establish a standard method for performing contamination surveys.

| Date: 4/1/2000 – NEW |
|---|
| **Department/Category:** Administrative |
| **Document Type:** Procedure |
| **Keyword Index:** radiological protection, radiological monitoring, source check, contamination surveys |
| **Approved by:** |

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- 5.3 Preliminary Actions
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  - 5.3.2 Instrument Use
- 5.4 Records

6.0 REFERENCES

- 6.1 Department of Energy
- 6.2 Nuclear Regulatory Commission
- 6.3 Other References

7.0 ATTACHMENTS

## 1.0 PURPOSE

To establish a standard method for performing contamination surveys.

## 2.0 SCOPE

This procedure addresses the surveying of personnel, equipment, materials and areas for contamination.

## 3.0 MAINTENANCE

The Director, Environmental, Health and Safety (EHS) Services is responsible for updating this procedure. Approval authority rests with TTFW's President and Chief Executive Officer. Suggestions for revision will be submitted to both the department responsible for updating the procedure and the Director, Administration and Compliance.

## 4.0 DEFINITIONS

See RP1-2. Glossary of Radiological Protection Terms.

## 5.0 DISCUSSION

### 5.1 Responsibilities

#### 5.1.1 Project Health Physicist (PHP)

The PHP is assigned to a project by the Director, Health Physics Programs. The PHP provides project-specific health physics guidance on an as needed basis. Working with the Health and Safety Officer (HSO), the PHP conducts all required radiological safety training, reviews project field procedures, performs radiation safety oversight, and conducts radiation incident investigations.

#### 5.1.2 Environmental Safety Supervisor (ESS)

The ESS is responsible for implementing the Radiological Protection Program required by the project-specific HASP and the Radiation Protection series of procedures. The ESS maintains a project site file of radiological protection training, dosimetry records, radiological incident

investigations, and other documentation pertinent to the Radiological Protection Program and provides the files in accordance with RP2-8, Records, at the conclusion of the project. The ESS may serve as the PHP if he or she possesses the adequate criteria in the area of health physics.

## 5.2 Equipment

### 5.2.1 Personnel Protective Equipment

Personnel protective equipment and radiation dosimetry for the amounts and types of radiation expected as identified in the Health and Safety Plan or the Radiological Work Permit.

### 5.2.2 Radiological Instrumentation

The PHP will determine the appropriate radiological monitoring equipment for a given project. This decision will be based upon:

- Known or suspected radionuclides of concern;
- Type of ionizing radiation and energy range;
- Type of media the radionuclides exist in (e.g., water, soil, air, etc.); and
- Detection limits which must be met for the particular task.

As field data becomes available, the ESS is responsible to inform the PHP of the data. During the course of a field program the type of instrumentation may change depending on the field results. The PHP is responsible to understand the limitations that exist with each type of instrumentation.

Table 1 presents basic information on the type of detectors available and their limitations. The information presented in these tables is intended to provide general information on the specifications and applications of different instruments.

The specific operating instructions and procedures for each instrument should be read and understood before operating any instrument. The information presented below is intended as generic startup information.

It is mandatory that this procedure be used in conjunction with a site-specific Health & Safety Plan.

## 5.3 Preliminary Actions

### 5.3.1 Instrumentation Check

See RP3-37, Portable Radiation Detection Instrumentation Operational Checks.

### 5.3.2 Instrumentation Use

Select the proper window for the type of contamination to be monitored (if appropriate).

Observe the instrument as you enter a potentially contaminated area. Watch for dramatic fluctuations in the instrument response. Any questions related to the response of the instrument should be directed to the PHP.

Use the instrument in the manner for which it is calibrated.

During contamination surveys beta/gamma G-M probes should be held ½ inch above the area surveyed and moved at a rate of 1 - 2 inch/sec. Alpha probes should be passed over the area at a distance of ¼ inch at a rate of 1 - 2 inch/sec. The audio mode of the survey instrument should be used to help identify "hot spots."

During outdoor scanning surveys with the NaI detector the probe should be swung in a serpentine motion as close to the ground as possible, without striking the ground. A rope handle should be fabricated to hold the probe with, never swing the detector by the cable. The audio mode, with ear phones, of the survey instrument should be used to help identify any areas of elevated activity.

For ratemeter-type instruments with analog displays, allow 6-10 seconds for the instrument to stabilize and record the reading on the Survey Record Sheet in the appropriate units.

For integrating instruments, collect counts for a predetermined time, typically 1-minute. Record the reading in the appropriate units as well as the counting time for each location of measurement on Attachment 1 or other form containing the same information.

**Table 1 - Available Radiological Contamination Survey Instruments**

| Instrument | Radiation Detected | Typical Ranges | Remarks |
|---|---|---|---|
| G-M Counters | $\alpha, \beta, \gamma$ | 80-80,000 cpm | Detection $\beta$ > 150 keV<br>> 20 keV for x-rays<br>Rugged<br>Rapid response<br>Strong energy dependence<br>Possible paralysis of response at high count rates<br>Sensitive to microwave fields<br>May be affected by ultraviolet light |
| Proportional Counters | | | |
| Air | $\alpha$ | 100 - 500,000 cpm | ~50% efficiency $2\pi$ geometry |
| Gas Flow | $\alpha$, low energy $\beta$ | ------- | ~50% efficiency $\alpha$<br>~35% efficiency $\beta$<br>Available in large sizes |
| Windowless Gas | $\alpha$, low energy $\beta$ | ------- | Tritium surface contamination – very difficult to use in the field |
| Scintillation Counters | | | |
| Alpha | $\alpha$ | 0 - 2,000,000 cpm | ZnS (Ag) |
| Low Energy Gamma | $\gamma$ and x-rays | 0 - 1,000,000 cpm | Thin NaI (Tl) 10-70 keV for $^{239}$Pu, $^{241}$Am, $^{125}$I and x-rays |

| | | | |
|---|---|---|---|
| Med. Energy Gamma | γ and x-rays | 0 - 1,000,000 cpm | 1"x1" to 2"x2" NaI (Tl) crystal for environmental gamma surveys *ALL SCINTILLATION COUNTERS are sensitive to magnetic fields* |

Notify personnel in the area of survey results, with emphasis on changed or extraordinary conditions.

Record the results on a survey sheet, see attachment 1, or in a logbook, at the direction of the PHP. Include the date, time, instrument model, serial number, and surveyor's name in the logbook.

### 5.3.3 Smear Surveys

Smear surveys are the primary means of characterizing removable contamination on surfaces and components. Below are a list of generic procedures when conducting smear surveys:
Identify the area that a sample shall be taken, the basic area is usually 100 $cm^2$;

- Remove one smear;
- Rub the smear on the suspected contaminated surface in a serpentine or circular motion covering at least 100 $cm^2$;
- Fold the paper over the smear, place the folded paper in a zip lock bag and insure the bag is sealed tightly. Record the date and time on the spaces provided on the paper
- Count the smear with portable instruments, if the instruments are capable of detecting contamination at the removable limit, or below. If the portable instruments are not capable, count the smear with a smear counter.

### 5.3.4 Large Area Wipes

Large area wipe (LAWs) samples may be taken as a means of identifying gross areas of contamination. Typically at least 1 $m^2$ is wiped with a large area wipe. In areas where LAWs identify contamination, smear samples should be taken.

Count the LAWs with portable instruments. Contact the PHP for action levels based on the isotopes of interest.

## 5.4 Records

Records of contamination surveys will be retained in accordance with RP2-8, Radiological Protection Records.

## 6.0 REFERENCES

## 6.1 Department of Energy

- DOE-STD-1098-99, Radiological Control

## 6.2 Nuclear Regulatory Commission

- NUREG-1507: "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions" (pre-published draft), Decmeber, 1997.

## 6.3 Other References

- Handbook of Health Physics and Radiological Health, 3rd Edition, 1998

## 7.0 ATTACHMENTS

Attachment 1 – TTFW Radiation/Contamination Survey Sheet

Attachment 2 – TTFW Radiation/Contamination Survey Map

Attachment 3 – TTFW Supplemental Radiation/Contamination Survey Sheet

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## Radiation/Contamination Survey Sheet

| SITE: | DATE: Yr Mo Day | TIME: | Page of |
|---|---|---|---|

| RWP # | CHARGE # | BLDG # |
|---|---|---|

SPECIFIC AREA OF SURVEY:

PURPOSE OF SURVEY:

### INSTRUMENT DATA

| Instrument Manufacturer(s) | Instrument Type(s) | Serial Number | Cal Due Date | Efficiency/CF |
|---|---|---|---|---|
| [] Bicron | [] ASP1 [] E120 [] E600 [] ESP1 | _____ | ___/___/___ | ___/___ |
| [] Eberline | [] HP260 [] Micro-Rem [] Model 3 | _____ | ___/___/___ | ___/___ |
| [] Ludlum | [] Model 16 [] RO-3C [] RSO-50E | _____ | ___/___/___ | ___/___ |
| [] _____ | [] SHP330 [] SHP340 [] SPA3 | _____ | ___/___/___ | ___/___ |
| [] _____ | [] _____ [] _____ | _____ | ___/___/___ | ___/___ |
| | [] _____ [] _____ | | | |

### RADIATION AND CONTAMINATION SURVEY RESULTS

Survey Map Attached: []Yes []No

| Sample Number | Description/Location | Total α (dpm/100 cm²) | Removable α (dpm/100 cm²) | Total βγ (dpm/100 cm²) | Removable βγ (dpm/100 cm²) | β mrad/hr | γ mrem/hr | Remarks |
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Remarks: Smears counted for _____/_____

SURVEYOR(S) NAME/ SIGNATURE/BADGE OR EMPLOYEE NUMBER _____/_____/_____

_____/_____/_____ _____/_____/_____

_____/_____/_____ _____/_____/_____

| Reviewed by: | Date: |
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| Radiation/Contamination Survey Map | | | |
|---|---|---|---|
| SITE: | DATE: Yr Mo Day | TIME: | Page of |
| RWP # | CHARGE # | BLDG # | |
| SPECIFIC AREA OF SURVEY: | | | |
| PURPOSE OF SURVEY: | | | |
| Reviewed by: | | Date: | |

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## Supplemental Radiation/Contamination Survey Sheet

| SITE: | DATE: Yr Mo Day | TIME: | Page of |
|---|---|---|---|

| RWP # | CHARGE # | BLDG # |
|---|---|---|

SPECIFIC AREA OF SURVEY:

PURPOSE OF SURVEY:

### RADIATION AND CONTAMINATION SURVEY RESULTS

Survey Map Attached: []Yes []No

| Sample Number | Description/Location | Total α (dpm/100 cm²) | Removable α (dpm/100 cm²) | Total βγ (dpm/100 cm²) | Removable βγ (dpm/100 cm²) | β mrad/hr | γ mrem/hr | Remarks |
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Remarks: Smears counted for _____/_____

SURVEYOR(S) NAME/ SIGNATURE/BADGE OR EMPLOYEE NUMBER _____/_____/_____

_____/_____/_____ _____/_____/_____

_____/_____/_____ _____/_____/_____

| Reviewed by: | Date: |
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# RP3-34 Collection of Soil Samples (Previously SCG-152)

**Purpose**
To establish a standard method for collecting surface soil samples for site radiological characterization. Surface soil samples are collected when there is a potential for soil contamination of radioactive material.

Date: 4/1/2000 – NEW
**Department/Category:** Administrative
**Document Type:** Procedure
**Keyword Index:** radiological protection, radiological monitoring, soil contamination, radiological soil samples
**Approved by:**


**TETRA TECH FW, INC**

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  - 5.1.2 Environmental Safety Supervisor
- 5.2 Sampling Equipment
  - 5.2.1 Personal Protective Equipment
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6.0 REFERENCES

- 6.1 U.S. Department of Transportation

7.0 ATTACHMENTS

## 1.0 PURPOSE

To establish a standard method for collecting surface soil samples for site radiological characterization. Surface soil samples are collected when there is a potential for radiological soil contamination.

## 2.0 SCOPE

This procedure addresses the collection of soil samples at increments of 6" (15 cm) for the purposes of radiological characterization.

## 3.0 MAINTENANCE

The Director, Environmental, Health and Safety (EHS) Services is responsible for updating this procedure. Approval authority rests with TTFW's President and Chief Executive Officer. Suggestions for revision will be submitted to both the department responsible for updating the procedure and the Director, Administration and Compliance.

## 4.0 DEFINITIONS

See RP1-2. Glossary of Radiological Protection Terms.

## 5.0 DISCUSSION

### 5.1 Responsibilities

#### 5.1.1 Project Health Physicist (PHP)

The PHP is assigned to a project by the Director, Health Physics Programs. The PHP provides project-specific health physics guidance on an as needed basis. Working with the Health and Safety Officer (HSO), the PHP conducts all required radiological safety training, reviews project field procedures, performs radiation safety oversight, and conducts radiation incident investigations.

#### 5.1.2 Environmental Safety Supervisor (ESS)

The ESS is responsible for implementing the Radiological Protection Program required by the project-specific HASP and the Radiation Protection series of procedures. The ESS maintains a

project site file of radiological protection training, dosimetry records, radiological incident investigations, and other documentation pertinent to the Radiological Protection Program and provides the files in accordance with RP2-8, Records, at the conclusion of the project. The ESS may serve as the PHP if he or she possesses the adequate criteria in the area of health physics.

## 5.2 Sampling Equipment

The following is a list of sampling equipment that may be needed to collect surface soil samples for radiological characterization using the methods described in this procedure:

- Sample containers, typically plastic or glass jars;
- Stainless steel cutter or other method for ensuring known area and depth, such as post-hole diggers with depth increments marked on the blades and handles to a depth of 24";
- Stainless steel scoop;
- Garden shears;
- Conventional digging tool (e.g., trowel, spade, shovel);
- Distilled water;
- Paper Towels;
- Waterproof Tape;
- Sample logbook;
- Sample labels;
- Ziploc bags;
- Cooler or other container for transporting samples (radiological samples do not have to be kept cool, unless other constituents that are being sampled for need to be kept cool);
- Chain of Custody Seals;
- Pancake Geiger-Muller (G-M) beta-gamma detector;
- Zinc-Sulfide (ZnS) alpha scintillator;
- Sodium-Iodide (NaI) gamma scintillator;
- Plastic sheeting or bucket;
- Trash Bags;
- Stainless Steel Bowl; and
- Stainless Steel Spatula.

### 5.2.1 Personnel Protective Equipment

Personnel protective equipment and radiation dosimetry for the amounts and types of radiation expected as identified in the Health and Safety Plan and/or Radiological Work Permit (RWP).

### 5.2.2 Radiation Detection Equipment

Radiation Survey Instruments appropriate to detect the radionuclides of concern and having a current calibration.

Note: For most gamma screening surveys a NaI scintillator, with a separate probe, is the preferred instrument. For alpha screening surveys a ZnS scintillator may be used. For beta-gamma screening, a pancake G-M instrument may be used.

## 5.3 Preliminary Actions

Prior to entering a radiological area, the types and levels of radioactivity must be determined to evaluate the amount of radiological exposure that the sampling crew will incur and to ensure adequate personnel protection. Performance of contamination surveys is described in Procedure RP3-33. Performance of radiation surveys is described in Procedure RP3-32. Personnel protection and monitoring requirements are addressed in the site Health and Safety Plan and/or the RWPs. To the extent possible, fill out labels and paperwork for samples prior to entering the radiological area. Plan your work to minimize the time required to complete all sampling and to avoid taking more supplies and materials into the radiological area than is necessary to complete the work identified in the Sampling and Analysis Plan.

Bag the NaI and G-M probes in clear plastic bags to help prevent their contamination. Consider bagging the meters as well in clear plastic bags.

NOTE: Do not bag the ZnS probe, as it will be unable to detect alpha contamination through the plastic bag.

### 5.3.1 Equipment Check

Perform survey instrument checks as specified in RP3-37.

## 5.4 Sampling Method

1. Locate the sampling location.

2. Take radiological readings as follows:

   - NaI at a height of 1 m above the sampling location;

- NaI on contact with the sampling location; and
- G-M and/or ZnS, as appropriate for the isotope(s) of concern, on contact with the sampling location

3. Use plastic sheeting to cover the adjacent ground surface. Equipment and supplies will be placed on this sheet or in a plastic bucket to prevent contamination. (Note: Do not place any items directly on the potentially contaminated surface soil.)

4. Use garden shears to clear vegetation from top soil. (Note: Save vegetation in ziploc bag if soil sampling is conducted in conjunction with vegetation sampling.)

5. Use the stainless steel cutter or other method that is designed to delineate the area and take a sample from 0" - 6" in depth.

6. Use the stainless steel scoop and spatula to trap and collect soil from the location into the stainless steel bowl, avoiding groundwater and runoff. Collect enough material (typically ~500 mg) to fill the sample container.

7. Homogenize the soil in the bowl, then transfer the soil to sample container, affix the lid, and seal with waterproof tape.

8. Wipe visible soil from exterior of the container with a dry paper towel.

9. Complete the information on the sample label (unique identifier, depth sample was taken from, date and time of sampling, name of sampler) and affix it to the container. Apply the Chain-of-custody seal.

10. Place NaI probe in the excavated hole and take a radiological reading, if this reading is twice the background reading, consider taking another sample from the next 6" depth.

11. Record information in the Sample Logbook, at a minimum to include all information from the sample label and all radiological readings taken at the sample location.

12. Place the sample in a Ziploc bag, seal, and place the bagged sample in the cooler (or other sample transport container).

13. Return any excess soil, stones, sticks, and/or vegetation to the excavation. (Note: Mixed waste land disposal restrictions may not allow this practice. If that is the situation, follow site-specific planning documents.)

14. Wipe excess soil from the scoop or bowl with a paper towel dampened with distilled water. (Note: Use as little water as possible in the decontamination process.) Continue to wipe excess soil from the scoop or bowl, as needed, until all visible soil has been removed, and then one additional time. Survey the scoop or bowl with the appropriate instrument, G-M and/or ZnS, as appropriate for the isotope(s) of concern. Store scoop and bowl in a clean plastic bag or the plastic bucket. Decontaminate the outside of the plastic bucket.

15. Survey your gloves with the appropriate instrument, G-M and/or ZnS, as appropriate for the isotope(s) of concern, if necessary decontaminate or replace with a new pair.

16. Place used towels, gloves, plastic sheet (if used), or other waste in a trash bag designated for radioactive waste.

17. Move to a new location and repeat Steps 1 through 16 until all samples are collected.

18. Perform a contamination survey on personnel and equipment in accordance with the site Health and Safety Plan and/or RWP.

### 5.5 Records

Records documenting the collection of soil samples and associated radiological measurements will be retained in accordance with RP2-8, Radiological Protection Records.

## 6.0 REFERENCES

### 6.1 American Society for Testing and Materials

- ASTM C998-90, Standard Practice for Sampling Surface Soil for Radionuclides

## 7.0 ATTACHMENTS

# RP3-36 Shipment and Transporting of Radiological Instrument Check Sources

| Date: 4/1/2000 – NEW |
|---|
| **Department/Category:** Administrative<br>**Document Type:** Procedure<br>**Keyword Index:** radiological protection, radiological monitoring, check sources, DOT<br>**Approved by:** |

**Purpose**

This procedure applies to the shipment and transporting of radiological instrument check sources to or from field projects.


**TETRA TECH FW. INC.**

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  - 5.1.4 Completion of Packaging
- 5.2 Transportation of Radiological Instrument Check Sources
- 5.3 Training Requirements
- 5.4 Records

6.0 REFERENCES

- 6.1 U.S. Department of Transportation

7.0 ATTACHMENTS

## 1.0 PURPOSE

The purpose of this procedure is to define Tetra Tech FW, Inc. (TTFW) standards for shipping and transporting of radiological instrument check sources.

Specifically this procedure implements the requirements of 49 CFR 171.15, 49 CFR 172 subpart H, 49 CFR 173.410, 49 CFR 173.421, 49 CFR 173.422, 49 CFR 173.425, and 49 CFR 173.443(a)

## 2.0 SCOPE

This procedure applies to the shipment and transporting of radiological instrument check sources to or from field projects.

## 3.0 MAINTENANCE

The Director, Environmental, Health and Safety (EHS) Services is responsible for updating this procedure. Approval authority rests with TTFW's President and Chief Executive Officer. Suggestions for revision will be submitted to both the department responsible for updating the procedure and the Director, Administration and Compliance.

## 4.0 DEFINITIONS

See RP1-2. Glossary of Radiological Protection Terms.

## 5.0 DISCUSSION

This procedure only applies to radioactive sources that are exempt quantities (less that the quantities listed in Attachment 3 of RP2-5).

### 5.1 Shipment of Radiological Instrument Check Sources

#### 5.1.1 Packaging

Each package of radioactive material will be in a small inner container that will be labeled with

- the radiation symbol;
- the wording "Caution - Radioactive Material";

- the isotope involved; and
- the quantity and date of the isotope.

The inner container will be placed in a larger cardboard, or equivalent, container with appropriate packaging to keep the inner package securely toward the center of the outer container. All openings/cracks in the outer container will be sealed with tape, as necessary, such that the exterior of the container is smooth and there are no areas where water could pool.

**NOTE: Do not seal the final side of the package until step 5.1.4**

### 5.1.2 Exterior Radiation Levels

The radiation level at any point on the external surface of the package must be less than 0.5 mrem/hr.

**NOTE: All radiological instrument check sources that are purchased by TTFW will have contact dose rates less than 0.5 mrem/hr, therefore the radiation level on the outside of the package will be less than 0.5 mrem/hr.**

All radiological instrument check sources boxes will have yellow "rad" tags on them stating the contact dose rates.

### 5.1.3 Exterior Surface Contamination Levels

The removable radioactive surface contamination levels on the external surfaces of the package must be less than 22 dpm/cm$^2$ beta-gamma and 2.2 dpm/100cm$^2$ alpha.

**NOTE: Only the applicable type of contamination must be analyzed for (i.e., an alpha check source does not have to be surveyed for beta-gamma also.)**

An area of 300 cm$^2$ on the exterior surface of the package will be wiped with an absorbent material, using moderate pressure. An area of approximately 3" x 3" on each exterior surface of the package should be wiped with the same wipe and counted with an appropriate radiological survey instrument. Correcting for area surveyed, the action levels are 6,600 dpm beta-gamma and 660 dpm alpha. This will be documented on attachment 1.

### 5.1.4 Completion of Packaging

After steps 5.1.1 - 5.1.3 are complete the documentation in the form of completed attachments 1 - 3 must be included inside the package.

Only ship the package via Federal Express, when completing the Federal Express airbill, check "No" under "Does this shipment contain dangerous goods?" In addition, the following wording **MUST** appear on the airbill, wherever it will fit: **"Radioactive Material – Excepted Quantity – Limited Quantity of Material."**

**NOTE: The United States Postal Service will not be used to transport radiological instrument check sources, due to more stringent requirements.**

## 5.2 Transport of Radiological Instrument Check Sources

All requirements as stated in section 5.1 apply to the transport of radiological instrument check sources by TTFW, or TTFW subcontractor, employees. Radiological instrument check sources may only be transported in personal, rental or company-owned vehicles.

**NOTE: Radiological instrument check sources may not be transported on commercial aircraft, other than in the possession of a freight company such as Federal Express or United Parcel Service.**

In the rare event of a fire, breakage, spillage, or suspected radioactive contamination spread involving the shipment of radioactive material the TTFW employee who is transporting the radiological instrument check source(s) by personal, rental, or company-owned vehicle will at the earliest practicable moment give notice to the Department of Transportation (DOT) by telephone on 800-424-8802. The notice must include the following information:

- Name of reporting employee;
- Name (Tetra Tech FW, Inc) and address of employer;
- Phone number where reporting employee can be contacted;
- Date, time, and location of the incident;
- Extent of injuries, if any;
- Classification (Class 7 - radioactive material), name (UN 2910 and isotope), and quantity of material.

The same information that is provided to the DOT must be provided to the Director of Health Physics Programs (423-481-8673) and the Project Health Physicist.

## 5.3 Training Requirements

Personnel that will be packaging radiological instrument check sources for shipping or transport or who will be transporting radiological instrument check sources must have successfully completed a Department of Transportation course.

## 5.4 Records

Records will be retained in accordance with RP2-8, Radiological Protection Records.

## 6.0 REFERENCES

### 6.1 U.S. Department of Transportation

- RAMREG-001-98, Radioactive Material Regulations Review
- 49 CFR 171, Transportation, General Information, Regulations, and Definitions
- 49 CFR 172 subpart H, Transportation, Training Requirements
- 49 CFR 173, Shippers-General Requirements for Shipments and Packaging

## 7.0 ATTACHMENTS

Attachment 1 - DOT Radiation/Contamination Survey Sheet

Attachment 2 - Radioactive Material - Exempt Quantity statement

Attachment 3 - Shipper's Certification for Radioactive Material

Attachment 1

TETRA TECH FW, INC.

## Contamination/Radiation Survey of Radiological Instrument Check Source for DOT Shipment

| | Gross cpm[1] | Background cpm | Net cpm[2] | Net dpm[3] | Action Level[4] (dpm) |
|---|---|---|---|---|---|
| Smear - alpha | | | | | 660 |
| Smear - Beta-gamma | | | | | 6,600 |

| Instrument | Model Number | Serial Number | Calibration Expiration Date | Efficiency |
|---|---|---|---|---|
| Alpha | | | | |
| Beta-gamma | | | | |

Surveyor's name and badge/employee number _____.

Location, Time, and Date of survey _____.

Source being shipped to (name and location) _____.

[1] cpm - counts per minute
[2] Net cpm = Gross cpm - Bkgd cpm
[3] Net dpm = Net cpm/efficiency
[4] Based upon a 300 $cm^2$ smear area by smearing a 3" x 3" area on each of 6 sides of the outer container.

Attachment 2

TETRA TECH FW, INC.

111 Union Valley Road
Oak Ridge, TN 37830
423-481-8662
423-481-8673

**RADIOACTIVE MATERIAL**

**EXEMPT QUANTITY**

THE CONTENTS OF THIS PACKAGE ARE EXEMPT FROM NRC OR ARGREEMENT STATE LICENSING REQUIREMENTS.

RADIOACTIVE MATERIAL - NOT FOR HUMAN USE - INTRODUCTION INTO FOODS, BEVERAGES, COSMETICS, DRUGS OR MEDICINALS OR INTO PRODUCTS MANUFACTURED FOR COMMERCIAL DISTRIBUTION IS PROHIBITED - EXEMPT QUANTITIES SHOULD NOT BE COMBINED - DO NOT BREAK, BEND, BURN OR MUTILATE - STORE IN CONTAINER PROVIDED WHEN NOT IN USE - HANDLE WITH FORCEPS TO PREVENT SCRATCHING OR DAMAGING THE ACTIVE SURFACE OF THE SOURCE.

RETURN EXEMPT QUANTITY SOURCES TO THE TTFW OAK RIDGE OFFICE.

Attachment 3

TETRA TECH FW, INC.

111 Union Valley Road
Oak Ridge, TN 37830
423-481-8662
423-481-8673

## SHIPPER'S CERTIFICATION FOR RADIOACTIVE MATERIAL

"This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package - limited quantity of material, UN 2910 and 49 CFR 173.422 for radioactive material, excepted package - instruments or articles, UN 2910."

I hereby certify that this package also conforms to all packaging requirements of the U.S. Department of Transportation and the International Air Transport Association (IATA) Rules and Regulations regarding the shipment of radioactive materials.

The materials are packed in strong, tight packages that will not leak during normal transport conditions, the radiation level on the exterior surface of the package **does not exceed** 0.5 mrem/hr., non-fixed (removable) contamination **does not exceed** applicable limits, and the outside of the inner container bears the marking "Radioactive".

No other labels are required.

### SOURCE INFORMATION

| Model No. | Isotope | Total Activity | Total Quantity | Serial No. |
|---|---|---|---|---|
| | | | | |

_____.  _____.

Authorized Signature  Date

# RP3-37 Portable Radiation Detection Instrumentation Operational Checks (Previously SCG-153)

**Purpose**

To provide a method for performing operational checks on portable radiation detection instruments.

Date: 4/1/2000 – NEW

**Department/Category:** Administrative
**Document Type:** Procedure
**Keyword Index:** radiological protection, radiological monitoring, source check, radiological instruments
**Approved by:**


**TETRA TECH FW, INC.**

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6.0 REFERENCES

ANSI Standard

7.0 ATTACHMENTS

## 1.0 PURPOSE

To provide a method for performing operational checks on portable radiation detection instruments.

## 2.0 SCOPE

This procedure addresses the performance of operational checks of portable radiation detection instrumentation.

## 3.0 MAINTENANCE

The Director, Environmental, Health and Safety (EHS) Services is responsible for updating this procedure. Approval authority rests with TTFW's President and Chief Executive Officer. Suggestions for revision will be submitted to both the department responsible for updating the procedure and the Director, Administration and Compliance.

## 4.0 DEFINITIONS

See RP1-2. Glossary of Radiological Protection Terms.

## 5.0 DISCUSSION

### 5.1 Responsibilities

#### 5.1.1 Project Health Physicist (PHP)

The PHP is assigned to a project by the Director, Health Physics Programs. The PHP provides project-specific health physics guidance on an as needed basis. Working with the Health and Safety Officer (HSO), the PHP conducts all required radiological safety training, reviews project field procedures, performs radiation safety oversight, and conducts radiation incident investigations.

#### 5.1.2 Environmental Safety Supervisor (ESS)

The ESS is responsible for implementing the Radiological Protection Program required by the project-specific HASP and the Radiation Protection series of procedures. The ESS maintains a project site file of radiological protection training, dosimetry records, radiological incident

investigations, and other documentation pertinent to the Radiological Protection Program and provides the files in accordance with RP2-8, Records, at the conclusion of the project. The ESS may serve as the PHP if he or she possesses the adequate criteria in the area of health physics.

## 5.2 Instrument Set-up Following Calibration

Record the following information on attachment 1, Source Check Sheet:

- Date;
- Name;
- Employee number;
- Instrument manufacturer;
- Instrument model number;
- Instrument serial number;
- Instrument calibration expiration date (if not specified, 1 year from last calibration);
- Probe/detector manufacturer;
- Probe/detector model number;
- Probe/detector serial number;
- Probe calibration expiration date (if not specified, 1 year from last calibration);
- Check source isotope;
- Check source identification number; and
- Check source recall date (if specified).

NOTE: If a particular line on attachment 1 is not applicable, note "N/A". Do not leave any blank lines.

### 5.2.1 Background Measurement

Provided that the instrument has a scaler option, three measurements of the background will be made, recorded, and averaged on attachment 1 prior to first use of the instrument following calibration.

If the instrument does not have a scaler option, one average measurement will be made with the instrument set on "slow" response, if applicable, after observing the instrument for approximately one minute.

An acceptable background value will be established by using the following formulas:

*Average Background Value - 20% = Minimum acceptable background value*
*Average Background Value + 20% = Maximum acceptable background value*

The minimum and maximum acceptable background values will be recorded on attachment 1.

### 5.2.2 Source Check Measurement

Provided that the instrument has a scaler option, three measurements of the check source will be made, recorded, and averaged on attachment 1 prior to first use of the instrument following calibration.

If the instrument does not have a scaler option, one average measurement will be made with the instrument set on "slow" response, if applicable, after observing the instrument for approximately one minute.

The source check value will be determined using the following formula:

*Gross Reading - Instrument Background = Source Check Value*

The source check value will be recorded on attachment 1 and an acceptable source check range established by using the following formulas:

*Source Check Value - 20% = Minimum acceptable source check*
*Source Check Value + 20% = Maximum acceptable source check*

The minimum and maximum acceptable source check values will be recorded on attachment 1.

## 5.3 Daily Source Check

Verify that the serial and model numbers on the Source Check Sheet correlate with the serial and model numbers on the instrument.

The date and the individuals initials and badge/employee number will be recorded on the next available line on the Source Check Sheet.

NOTE: If a particular line on attachment 1 is not applicable, note "N/A". Do not leave any blank lines.

### 5.3.1 Current Calibration

All instruments must be in current calibration. Check the expiration date on the calibration sticker on the instrument and the Source Check Sheet to ensure the instrument calibration has not expired. Do not use the instrument if it is past due for calibration. Survey instruments are considered past due for calibration if the "due date" has passed or if the latest calibration is more than one year old. If there is a question regarding the specified calibration frequency for the instrument, contact the Project Health Physicist (PHP).

Record YES or NO on the Source Check Sheet whether or not the instrument is within the calibration date.

### 5.3.2 Physical Condition

Check the physical condition of the instrument. Look for tears or punctures in the detector window (where applicable), cracks or broken insulation on cables, signs of battery leakage, etc. If any defects are found, do not use the instrument.

Record YES or NO on the Source Check Sheet whether or not the physical condition is acceptable.

### 5.3.3 Battery Check

Perform a battery check. If the battery voltage is not within the manufacturer's specification, replace the batteries with the appropriate type and number. If the voltage is still not within specification, remove instrument from service and return to manufacturer or authorized repair organization for repair and calibration.

Record YES or NO on the Source Check Sheet whether or not the battery check was acceptable.

### 5.3.4 Background Measurement

Determine the instrument response to background radiation. The daily background measurement should fall within 20% of the average background established for that instrument on the first day of use. If the background reading falls outside these bounds, do not use the instrument. Notify the PHP.

Record the background measurement on the Source Check Sheet.

### 5.3.5 Check Source Measurement

Check the instrument response with a check source. Utilize the same check source in the same geometry upon each use. A check source placed in a reproducible position near the detector should give an indication within 20% of an average value established on the first day of use. If the check source reading does not fall within these bounds, do not use the instrument. Notify the PHP.

Record the source check measurement on the Source Check Sheet.

## 5.4 Records

Records of instrumentation operational checks will be retained in accordance with RP2-8, Radiological Protection Records.

## 6.0 REFERENCES

### 6.1 ANSI Standards

ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration

## 7.0 ATTACHMENTS

Attachment 1 - Portable Radiation Detection Instrumentation Source Check Sheet

## Attachment 1

TETRA TECH FW, INC.

# Source Check Sheet

| | | | | | |
|---|---|---|---|---|---|
| Date | | Name | | Employee No. | |

| | | | |
|---|---|---|---|
| **Instrument** Manufacturer | | **Probe/Detector** Manufacturer | |
| Model No. | | Model No. | |
| Serial No. | | Serial No. | |
| Calibration Expiration Date | | Calibration Expiration Date | |

| | | | | | |
|---|---|---|---|---|---|
| **Check Source** | | **Efficiency** | | | |
| Isotope | | Identification No. | | Recall Date | |

| | | | | |
|---|---|---|---|---|
| **Initial Background Measurements** | | | **Units** | |
| 1. | 2. | 3. | Average | |
| Min Background Value | | | Max Background Value | |

| | | | | |
|---|---|---|---|---|
| **Initial Source Check Measurements** | | | **Units** | |
| 1. | 2. | 3. | Average | |
| Min. Source Check Value | | | Max Source Check Value | |

**Daily Source and Background Checks**

| Date | Initials | Employee No. | Current Calibration (Y/N) | Acceptable Physical Condition (Y/N) | Acceptable Battery Check (Y/N) | Background (cpm Or mR/hr) | Source Check (cpm Or mR/hr) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
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TETRA TECH FW, INC.

# Source Check Continuation Sheet

| Date | | Name | | Employee No. | |
|---|---|---|---|---|---|

| **Instrument** Manufacturer | | **Probe/Detector** Manufacturer | |
|---|---|---|---|
| Model No. | | Model No. | |
| Serial No. | | Serial No. | |
| Calibration Expiration Date | | Calibration Expiration Date | |

| **Check Source** | | **Efficiency** | | | |
|---|---|---|---|---|---|
| Isotope | | Identification No. | | Recall Date | |

**Daily Source and Background Checks**

| Date | Initials | Employee No. | Current Calibration (Y/N) | Acceptable Physical Condition (Y/N) | Acceptable Battery Check (Y/N) | Background (cpm Or mR/hr) | Source Check (cpm Or mR/hr) |
|---|---|---|---|---|---|---|---|
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# RP3-38 Radiological Screening Surveys (Previously SCG-151)

**Purpose**
To establish a standard method for conducting initial radiological screening surveys and measurements in support of radiological assessment and characterization activities.

Date: 4/1/2000 - NEW
**Department/Category:** Administrative
**Document Type:** Procedure
**Keyword Index:** radiological protection, radiological monitoring, radiological screening
**Approved by:**

**TETRA TECH FW, INC.**

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## 1.0 PURPOSE

To establish a standard method for conducting initial radiological screening surveys and measurements in support of radiological assessment and characterization activities.

## 2.0 SCOPE

This procedure addresses the performance of the initial radiological screening surveys for the radiological evaluation of soil or other surfaces (concrete or asphalt), indoors or out-of-doors. This procedure shall be used in conjunction with a site-specific Health and Safety Plan and a Survey or Work Plan, which is developed in accordance with the corporate EHS procedures.

This procedure would be appropriate for performing a MARSSIM type survey.

The screening survey typically consists of two types of measurements: scanning, and measuring levels of direct radiation (surface activity and exposure rates). The measurements are performed to substantiate and, where necessary, better define the identity of potential radioactive contaminants and the general extent of residual activity.

The procedure is useful for alpha, beta, and gamma emitting radionuclides, with the following limitations:

- Other sources of radiation exposure, i.e., radioactive materials in drums, pipes, or process equipment may interfere with the contamination assessment for gamma emitters, and may preclude the use of this procedure. The potential for the presence of radiation sources other than surface contamination should be evaluated prior to initiating the screening survey.

- Detection sensitivity for alpha or beta particles is reduced by the type of contaminated matrix (i.e., soil, asphalt, or concrete), matrix moisture content, layers of paint, vegetation, and other factors. These influences on the survey instrument sensitivity should be considered in planning the screening survey as well as interpreting the results.

- Scanning surveys for alpha or beta emitters must be performed more slowly than those for gamma emitters due to the lower sensitivity and longer response times of the instrumentation required. This fact should be taken into consideration and balanced against time and cost constraints when planning a screening survey.

## 3.0 MAINTENANCE

The Director, Environmental, Health and Safety (EHS) Services is responsible for updating this procedure. Approval authority rests with TTFW's President and Chief Executive Officer. Suggestions for revision will be submitted to both the department responsible for updating the procedure and the Director, Administration and Compliance.

## 4.0 DEFINITIONS

See RP1-2. Glossary of Radiological Protection Terms.

## 5.0 DISCUSSION

This procedure shall be used in conjunction with a site-specific Health & Safety Plan and a Survey or Work Plan. Prior to initiating a radiation screening survey, the PHP must obtain written confirmation from the Field Operations Leader (FOL) that radiation exposure in the survey area has been determined to be within safety limits specified in the Health and Safety Plan. If there is insufficient information to make this determination, a radiation survey shall be performed as specified in RP3-32.

### 5.1 Responsibilities

#### 5.1.1 Project Health Physicist (PHP)

The PHP is assigned to a project by the Director, Health Physics Programs. The PHP provides project-specific health physics guidance on an as needed basis. Working with the Health and Safety Officer (HSO), the PHP conducts all required radiological safety training, reviews project field procedures, performs radiation safety oversight, and conducts radiation incident investigations.

#### 5.1.2 Environmental Safety Supervisor (ESS)

The ESS is responsible for implementing the Radiological Protection Program required by the project-specific HASP and the Radiation Protection series of procedures. The ESS maintains a project site file of radiological protection training, dosimetry records, radiological incident investigations, and other documentation pertinent to the Radiological Protection Program and provides the files in accordance with RP2-8, Records, at the conclusion of the project. The ESS may serve as the PHP if he or she possesses the adequate criteria in the area of health physics.

### 5.2 Equipment

#### 5.2.1 Personnel Protective Equipment

Personnel protective equipment and radiation dosimetry for the amounts and types of radiation expected as identified in the Health and Safety Plan or the Radiological Work Permit.

#### 5.2.2 Radiological Instrumentation

Radiological instrumentation appropriate to detect the radionuclides of concern and having a current calibration. The calibration shall be made to the type and energy of radiation relevant to the survey. (Note: For most gamma screening surveys a NaI[Tl] scintillation instrument is the preferred instrument. For alpha screening surveys a zinc sulfide scintillation instrument or a gas-flow proportional detector may be used. For beta screening surveys a pancake Geiger-Muller instrument or a gas-flow proportional detector may be used.) See RP3-33 concerning contamination surveys.

## 5.3 Preliminary Actions

### 5.3.1 Review the Survey Plan

Review the survey plan and clarify any questions or concerns with the PHP. The survey plan written by the PHP establishes the technical approach and requirements for performing the screening survey. At a minimum the survey plan should include the following information:

- Types of measurements;
- Location of measurements;
- Number of measurements;
- Required instrumentation;
- QA/QC requirements; and
- Contaminant action levels.

### 5.3.2 Instrumentation Check

See RP3-37, Portable Radiation Detection Instrumentation Operational Checks.

### 5.3.3 Instrumentation Use

Select the proper window(s) for the type(s) of radiation/contamination to be monitored (if appropriate).

The specific operating instructions and procedures for each instrument should be read and understood before operating any instrument. The information presented below is intended as generic startup information.

Observe the instrument as you enter a survey area. Watch for dramatic fluctuations in the instrument response. Any questions related to the response of the instrument should be directed to the PHP.

Use the instrument in the manner for which it is calibrated.

### 5.3.4 Establish Background Level

Determine the working background level at an area known to be free of radioactive contamination. At a minimum, there should be two working background locations. The number and locations of working background measurements should be specified in the Survey Plan. If not, consult the PHP for the locations. (Note: Working background measurements should be made with the detector in the same relative position to the surface of interest as that planned for the screening survey, e.g., at 1 meter for exposure rate measurements or near-contact for contamination surveys.) Record the working background on the Radiation/Contamination Survey Sheet.

## 5.4 Screening Surveys

Determine the survey path to be followed by reviewing the Survey Plan and consultation with the FOL and PHP. For gamma surveys, hold the detector as close as possible (e.g., 2.5 cm or 1 inch) to the contaminated surface and proceed along the survey path at a rate of 0.5 m/sec (1.6 ft/sec) while slowly swinging the detector in a serpentine pattern. (Note: Do NOT hold the detector by the cable. Means of supporting the detector must be devised to avoid damaging the connector cable. A rope often works well and provides minimal backscatter.)

See RP3-33 regarding contamination surveys.

Monitor the instrument audio output carefully while scanning for areas of elevated radiation or contamination above the working background level. When an area of elevated activity is detected, stop, allow the display to stabilize or preferably utilize the scaler function, and record the reading and location on the Radiation/Contamination Survey Sheet (Attachment 1). Consider placing pin-flags or other non-permanent marking methods to denote the location of elevated activity. Continue the survey.

## 5.5 Direct Measurements

Determine the measurement locations from the Survey Plan. Proceed to a measurement location and position the detector as follows depending on measurement to be made:

Exposure Rate - 1 m above the surface
Beta or Gamma Contamination - < 2 cm from surface
Alpha Contamination - < 1 cm from surface

For ratemeter-type instruments with analog displays, allow 6-10 seconds for the instrument to stabilize and record the reading on the Radiation/Contamination Survey Sheet in the appropriate units.

For integrating instruments, collect counts for a predetermined time, typically 1-minute. Record the reading in the appropriate units as well as the counting time for each location of measurement on the Radiation/Contamination Survey Sheet in the appropriate units.

Continue for the remainder of the measurement locations.

## 5.6 Records

Records of radiological screening surveys will be retained in accordance with RP2-8, Radiological Protection Records.

# 6.0 REFERENCES

## 6.1 Department of Energy

- DOE-STD-1098-99, Radiological Control

## 6.2 Nuclear Regulatory Commission

- NUREG-1507: "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions" (pre-published draft), December, 1997.

## 6.3 Other References

- Handbook of Health Physics and Radiological Health, 3rd Edition, 1998

# 7.0 ATTACHMENTS

Attachment 1 – TTFW Radiation/Contamination Survey Sheet

Attachment 2 – TTFW Radiation/Contamination Survey Map

Attachment 3 – TTFW Supplemental Radiation/Contamination Survey Sheet

TETRA TECH FW, INC.

Tracking Number:

## Radiation/Contamination Survey Sheet

| SITE: | DATE: Yr Mo Day | TIME: | Page of |
|---|---|---|---|

| RWP # | CHARGE # | BLDG # |
|---|---|---|

SPECIFIC AREA OF SURVEY:

PURPOSE OF SURVEY:

### INSTRUMENT DATA

| Instrument Manufacturer(s) | Instrument Type(s) | Serial Number | Cal Due Date | Efficiency/CF |
|---|---|---|---|---|
| ▯ Bicron | ▯ ASP1 ▯ E120 ▯ E600 ▯ ESP1 | _____ | ___/___/___ | ___/___ |
| ▯ Eberline | ▯ HP260 ▯ Micro-Rem ▯ Model 3 | _____ | ___/___/___ | ___/___ |
| ▯ Ludlum | ▯ Model 16 ▯ RO-3C ▯ RSO-50E | _____ | ___/___/___ | ___/___ |
| ▯ _____ | ▯ SHP330 ▯ SHP340 ▯ SPA3 | _____ | ___/___/___ | ___/___ |
| ▯ _____ | ▯ _____ ▯ _____ | _____ | ___/___/___ | ___/___ |
| | ▯ _____ ▯ _____ | | | |

### RADIATION AND CONTAMINATION SURVEY RESULTS

Survey Map Attached: ▯Yes ▯No

| Sample Number | Description/Location | Total α (dpm/100 cm²) | Removable α (dpm/100 cm²) | Total βγ (dpm/100 cm²) | Removable βγ (dpm/100 cm²) | β mrad/hr | γ mrem/hr OR cpm | Remarks |
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| | | | | | | | | |

Remarks: Smears counted for _____/_____

SURVEYOR(S) NAME/ SIGNATURE/BADGE OR EMPLOYEE NUMBER _____/_____/_____

_____/_____/_____ _____/_____/_____

_____/_____/_____ _____/_____/_____

| Reviewed by: | Date: |
|---|---|

TETRA TECH FW, INC.

| Tracking Number: |
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## Radiation/Contamination Survey Map

| SITE: | DATE: Yr Mo Day | TIME: | Page of |
|---|---|---|---|

| RWP # | CHARGE # | BLDG # |
|---|---|---|

SPECIFIC AREA OF SURVEY:

PURPOSE OF SURVEY:

| Reviewed by: | Date: |
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TETRA TECH FW, INC.

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## Supplemental Radiation/Contamination Survey Sheet

| SITE: | DATE: Yr Mo Day | TIME: | Page of |
|---|---|---|---|

| RWP # | CHARGE # | BLDG # |
|---|---|---|

SPECIFIC AREA OF SURVEY:

PURPOSE OF SURVEY:

### RADIATION AND CONTAMINATION SURVEY RESULTS

Survey Map Attached: []Yes []No

| Sample Number | Description/Location | Total α (dpm/100 cm²) | Removable α (dpm/100 cm²) | Total βγ (dpm/100 cm²) | Removable βγ (dpm/100 cm²) | β mrad/hr | γ mrem/hr OR cpm | Remarks |
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Remarks: Smears counted for _____/_____

SURVEYOR(S) NAME/ SIGNATURE/BADGE OR EMPLOYEE NUMBER _____/_____/_____

_____/_____/_____ _____/_____/_____

_____/_____/_____ _____/_____/_____

| Reviewed by: | Date: |
|---|---|